SOIL SURVEY

Garfield County Oklahoma

OUR SOIL • OUR STRENGTH

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
OKLAHOMA AGRICULTURAL EXPERIMENT STATION
Issued October 1967

HOW TO USE THIS SOIL SURVEY

Major fieldwork for this survey was done in the period 1956 to 1963. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1963. This survey was made cooperatively by the Soil Conservation Service and the Oklahoma Agricultural Experiment Station, as part of the technical assistance furnished to the Garfield County Soil and Water Conservation District.

THIS SOIL SURVEY of Garfield County, Okla., contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

All the soils of Garfield County are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and the page for the capability unit in which the soil has been placed. It also lists the range site and woodland suitability group of each soil.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils in the soil descriptions and in the discussions of the interpretative groupings.

Foresters and others can refer to the section "Management of Woodland for Windbreaks and Post Lots," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Wildlife."

Ranchers and others interested in range can find, under "Management of Rangeland," groupings of the soils according to their suitability for range, and also the plants that grow on each range site.

Engineers and builders will find under "Use of Soils in Engineering" tables that give engineering descriptions of the soils in the county and that name soil features that affect engineering practices and structures.

Scientists and others can read about how the soils were formed and how they are classified in the section "Classification and Morphology of Soils."

Students, teachers, and others will find information about soils and their management in various parts of the text.

Newcomers in Garfield County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Facts About the County."

U S. GOVERNMENT PRINTING OFFICE: 1967

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Contents

NOTICE TO LIBRARIANS

Series year and series number are no longer shown on soil surveys. See explanation on the next page.

Issued October 1967

EXPLANATION

Series Year and Series Number

Series year and number were dropped from all soil surveys sent to the printer after December 31, 1965. Many surveys, however, were then at such advanced stage of printing that it was not feasible to remove series year and number. Consequently, the last issues bearing series year and number will be as follows:

- Series 1957, No. 23, Las Vegas and Eldorado Valleys Area, Nev.
- Series 1958, No. 34, Grand Traverse County, Mich.
- Series 1959, No. 42, Judith Basin Area, Mont.
- Series 1960, No. 31, Elbert County, Colo. (Eastern Part)
- Series 1961, No. 42, Camden County, N.J.
- Series 1962, No. 13, Chicot County, Ark.
- Series 1963, No. 1, Tippah County, Miss.

Series numbers will be consecutive in each series year, up to and including the numbers shown in the foregoing list. The soil survey for Tippah County, Miss., will be the last to have a series year and series number.

SOIL SURVEY OF GARFIELD COUNTY, OKLAHOMA

BY BILL SWAFFORD, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH OKLAHOMA AGRICULTURAL EXPERIMENT STATION

GARFIELD COUNTY is in the north-central part of Oklahoma (fig. 1). The total land area is 1,054 square miles.

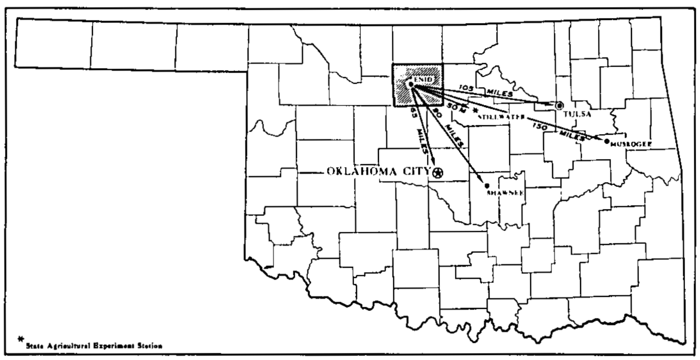


Figure 1.—**Location of Garfield County in Oklahoma.**

Enid, the county seat and largest town, is just northwest of the center of the county.

How This Soil Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Garfield County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock, and many facts about the soils. They dug or bored many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide uniform procedures. To use this survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Tabler and Bethany, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in these characteristics that affect their behavior in the natural, undisturbed landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such difference in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Port silt loam and Port clay loam are two soil types in the Port series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Grant silt loam, 3 to 5 percent slopes, is one of several phases of Grant silt loam, a soil type that ranges from nearly level to moderately steep.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodland, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this survey was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Kingfisher-Lucien complex, 5 to 8 percent slopes, eroded.

Other areas shown on most soil maps are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Broken alluvial land, and are called land types rather than soils.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, among them farmers, ranchers, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil surveys. On the basis of the yield and practice tables and other data, the soil scientists set up trial groups. They test these by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Garfield County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The seven general soil associations of Garfield County are described on the following pages.

1. Pratt-Carwile-Shellabarger Association

Deep, sandy and loamy, level to gently sloping soils of the uplands

This association is made up of deep sandy soils of the uplands. It makes up about 12 percent of the county, and occurs in several areas west of Enid. The soils in this association formed under tall grasses in sandy and loamy deposits.

The principal soils in this association are the Pratt, Carwile, and Shellabarger (fig. 2). The Pratt soils are undulating or hummocky. They have a brown, coarse-textured surface layer about 14 inches thick. Their subsoil is a dark-brown, rapidly permeable, loamy sand with weak granular structure.

The Carwile soils are in nearly level areas or slight depressions. They have a medium textured or moderately coarse textured surface layer that is very dark grayish brown and 9 to 12 inches thick. Their subsoil is compact, blocky, very slowly permeable clay mottled with gray and brown.

The Shellabarger soils are nearly level or gently undulating, well-drained soils. They have a surface of grayish-brown fine sandy loam and a subsoil of brown or dark-brown sandy clay loam.

Minor soils in this association are the Meno. They have a deeper surface layer than the Shellabarger, but have less capacity to store moisture and are coarser textured.

Wind erosion, moisture conservation, and maintenance of organic matter are the main concerns of management. Mechanical means of erosion control, such as terracing, cannot be successfully applied to most of the soils, because they are sandy or have uneven relief. Some of the erosion control measures that can be successfully applied are proper management of crop residue, cover cropping, and establishing of native grasses.

About two-thirds of this association is cultivated to small grains, grain sorghum, and millet. Yields are fair to good. The land not cultivated is in native or introduced pasture grasses. Forage yields are fair to good where the soils are properly managed. Most water for livestock comes from shallow wells because moisture seeps through the soils rapidly and sites for impounding water are few.

2. Port-Reinach Association

Deep, nearly level, loamy soils of the flood plains

Large areas of this association occur throughout the county on broad nearly level or gently sloping flood plains adjacent to large streams, such as Black Bear, Red Rock, Turkey, and Skeleton Creeks. Smaller areas lie along Hackberry, Otter, Wolf, and Bitter Creeks. This association makes up about 8 percent of the county.

All the soils are subject to flooding, but the floods are so infrequent and of such short duration that they seldom damage crops severely. The soils formed in fairly recent alluvial sediments. Fertility is high, and yields are high when the soils are properly managed.

Port soils make up about 56 percent of this association, and Reinach soils about 24 percent. Of lesser extent are the Pulaski soils (12 percent), Broken alluvial land (5

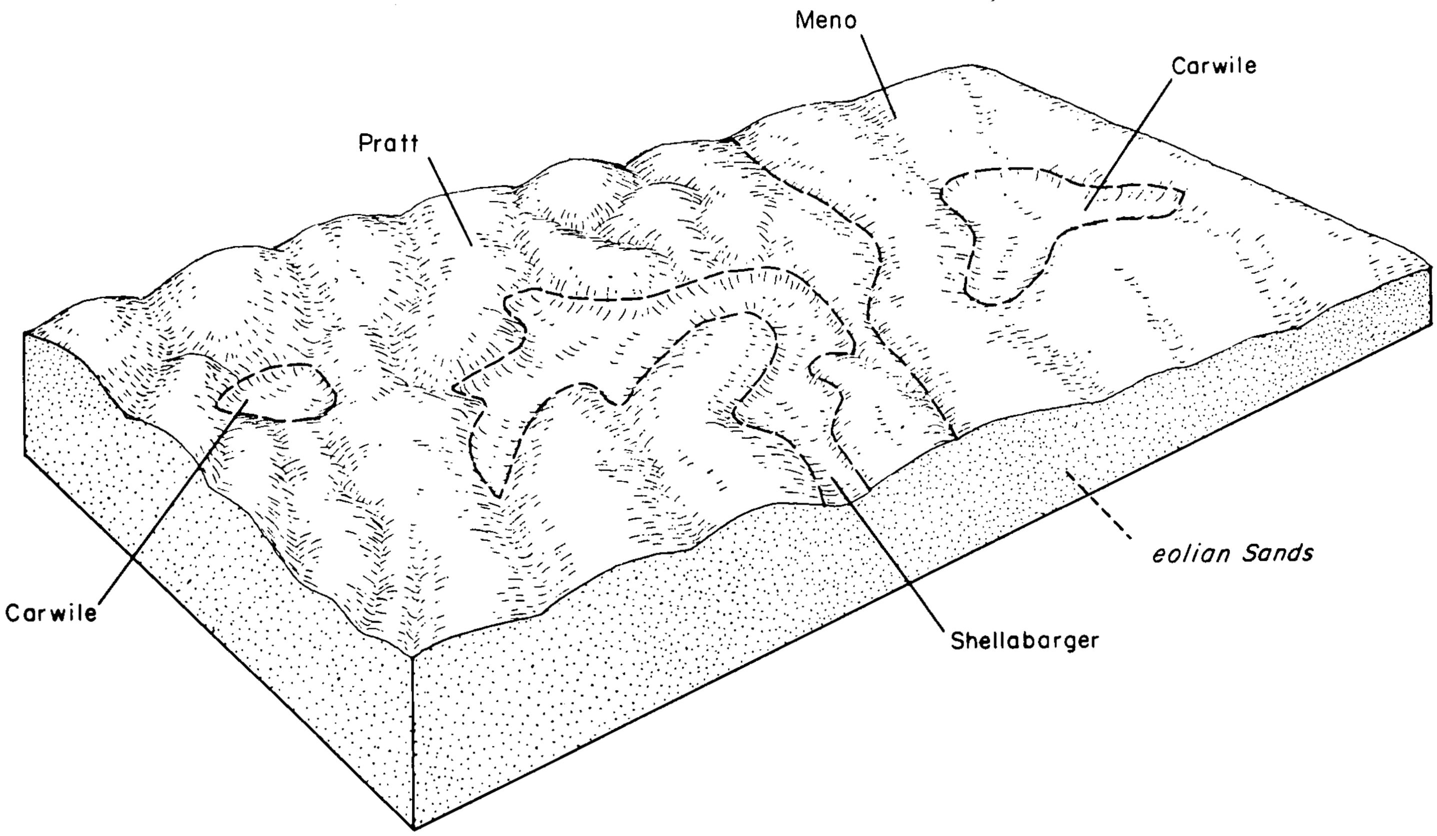


Figure 2.—Typical pattern of soils in the Pratt-Carwile-Shellabarger soil association.

percent), Miller clay (1 percent), Miller-Slickspots complex (1 percent), and Reinach-Slickspots complex (1 percent).

Port and Reinach soils are on the higher parts of the flood plains. The Pulaski and Miller soils generally are at somewhat lower elevations, but in some areas the Miller soils are in slight depressions. The Port soils are darker than the Reinach or Pulaski soils and have slightly more distinct structure. The Pulaski soils are sandier and more stratified than either the Port or the Reinach soils. The Miller is a reddish-brown clayey soil that takes moisture slowly. The Reinach-Slickspots and Miller-Slickspots complexes are saline or alkali soils that are hard to cultivate and that require special treatment.

The main concerns in managing this association are conservation of moisture, maintenance of soil structure, treatment of slickspot areas, and control of floods. The greatest loss of moisture is through evaporation.

Most of this association is cultivated to small grains and alfalfa; yields are high during years of normal rainfall.

3. Grant-Pond Creek Association

Deep, loamy, nearly level to moderately steep soils of the uplands

This association consists of deep loamy soils of the uplands. Although there are some steep areas next to drains, most of this association is nearly level to gently sloping. The association begins just west of Enid and covers about three-fourths of the western part of the county. Little of this association is east of U.S. Highway No. 81. It makes up about 20 percent of the county.

In this association are mature soils that formed under tall grasses. Their fertility is high, and they are in good tilth. In the lower part of their profile, they do not contain so much clay or have so strong a blocky structure as soils of association 5. Though most soils in this association have been cultivated a number of years, the supply of organic matter is still comparatively high, and yields of all crops generally are high. Yields are limited mainly by amount of moisture available.

The dominant soils are the Grant and the Pond Creek (fig. 3). The Grant are deep and well-drained soils on nearly level to steeply sloping uplands. They formed in loamy soil material rich in plant nutrients. Their capacity to take in and hold moisture is high. Their surface layer is a reddish-brown moderately permeable silt loam about 16 inches thick. The subsoil is a heavy silt loam, neutral to mildly alkaline.

Pond Creek are deep, well-drained soils that formed in calcareous loess on the uplands. They are more nearly level than the Grant soils and are slightly finer textured in the lower part. Because they are nearly level, Pond Creek soils are well suited to the farm machinery used in cultivating and harvesting small grains, alfalfa, and other crops commonly grown in the county.

The Nash and Kingfisher are minor soils in this association. The Nash are moderately deep, well-drained upland soils that formed in material derived from weakly consolidated, interbedded sandstone and siltstone. Nash soils

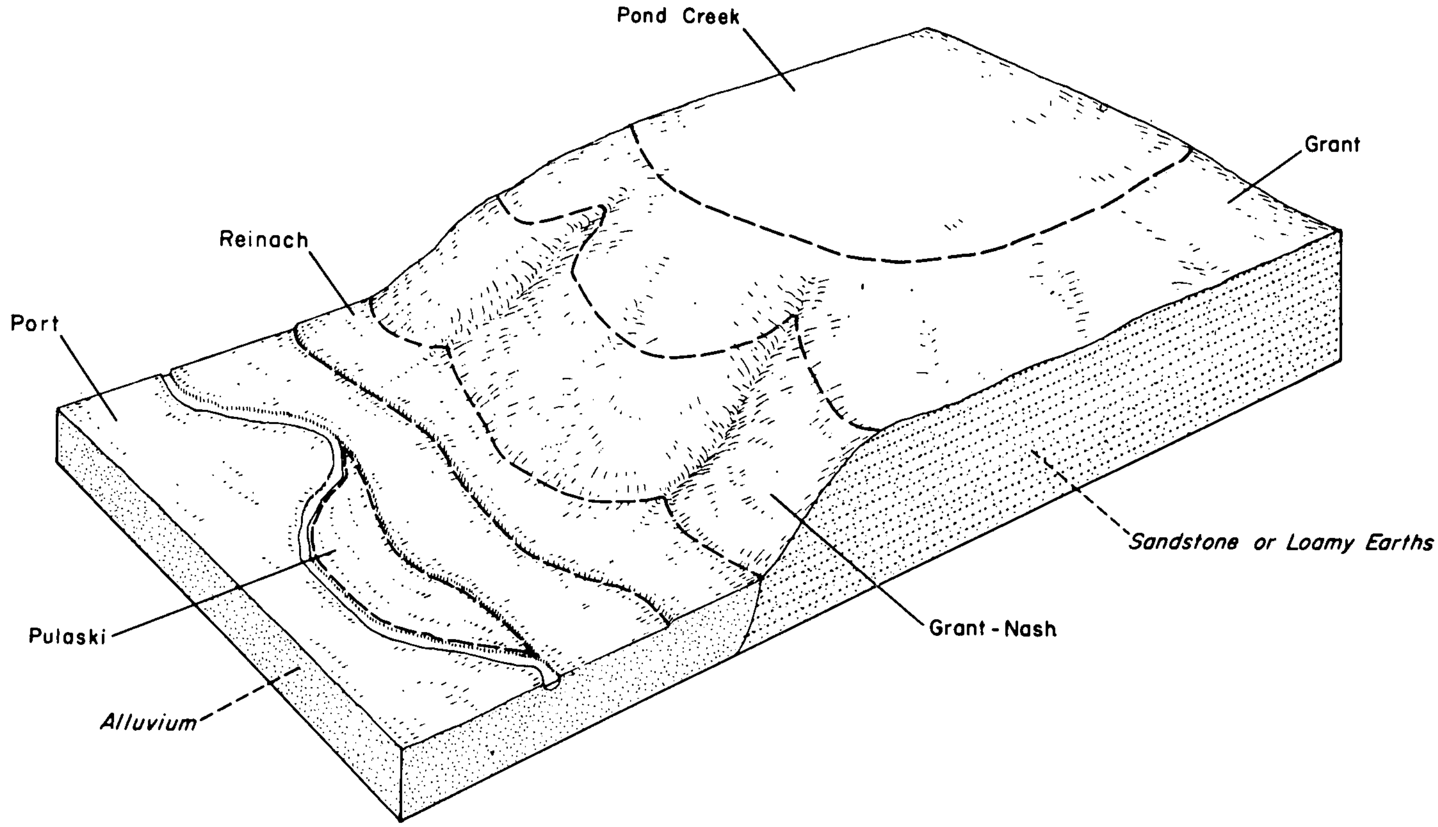


Figure 3.—**Typical pattern of soils in the Grant-Pond Creek association, and Port, Reinach, and Pulaski soils of soil association 2 on the bordering flood plains.**

are generally on steeper slopes than the Grant or Pond Creek soils, so they lose more moisture as runoff, and because they are not so deep, store less of the moisture they do absorb.

Kingfisher soils occur in the southern parts of this association. These are deep, well-drained soils on gently to strongly sloping uplands. They formed in material from red clay beds or shale. They have more clay in the lower part than the Grant soils, and they are not so dark as the Pond Creek soils.

Conserving moisture, controlling water erosion on steep slopes, and maintaining soil structure and fertility are the concerns of management if continued maximum production is to be achieved. Moisture can be conserved by stubble mulch tillage, which also helps to maintain the supply of organic matter and to preserve soil structure.

Nearly all of this association is cultivated to wheat, oats, barley, and alfalfa. Long, narrow, steeply sloping areas next to drains are left in native vegetation and used for grazing sheep and other livestock.

4. Renfrow-Vernon-Kirkland Association

Deep and shallow, nearly level to gently sloping upland soils with a clayey subsoil

This association consists of nearly level to gently sloping, moderately well drained soils. It occupies about 34 percent of the county, and is largely in the east-central part.

Most of the soils have a clayey subsoil and are calcareous in the lower part. Their surface layer is either medium textured or moderately fine textured.

The dominant soils are the Renfrow, Vernon, and Kirkland (fig. 4). Both the Kirkland and Renfrow are deep, but the Kirkland are the deeper of the two. The Vernon is a reddish, calcareous, shallow soil derived from shale.

The Norge, a minor soil in this association, is a deep upland soil that formed in old alluvium. Generally, it lies close to the major streams, and the greater part of it is gently sloping.

Breaks-Alluvial land complex, another minor mapping unit, is in the natural drainageways, which range up to 1,100 feet in width. It consists of mixed, mostly gently sloping alluvial soils, and of narrow areas of steep, Vernon nonarable soils on the side slopes of the drainageways. The Vernon soils are used for grazing. Grazing is good on the alluvial part because extra moisture is received through frequent flooding and internal seepage from side slopes. The native vegetation is mostly short grasses, which are easily overgrazed and are then replaced by weedy plants.

Most of this soil association is cultivated to wheat, oats, and barley.

5. Kirkland-Bethany-Tabler Association

Deep, nearly level, loamy soils of the uplands

This association is on a broad, nearly level plain in the east-central part of the county. It is drained to the east

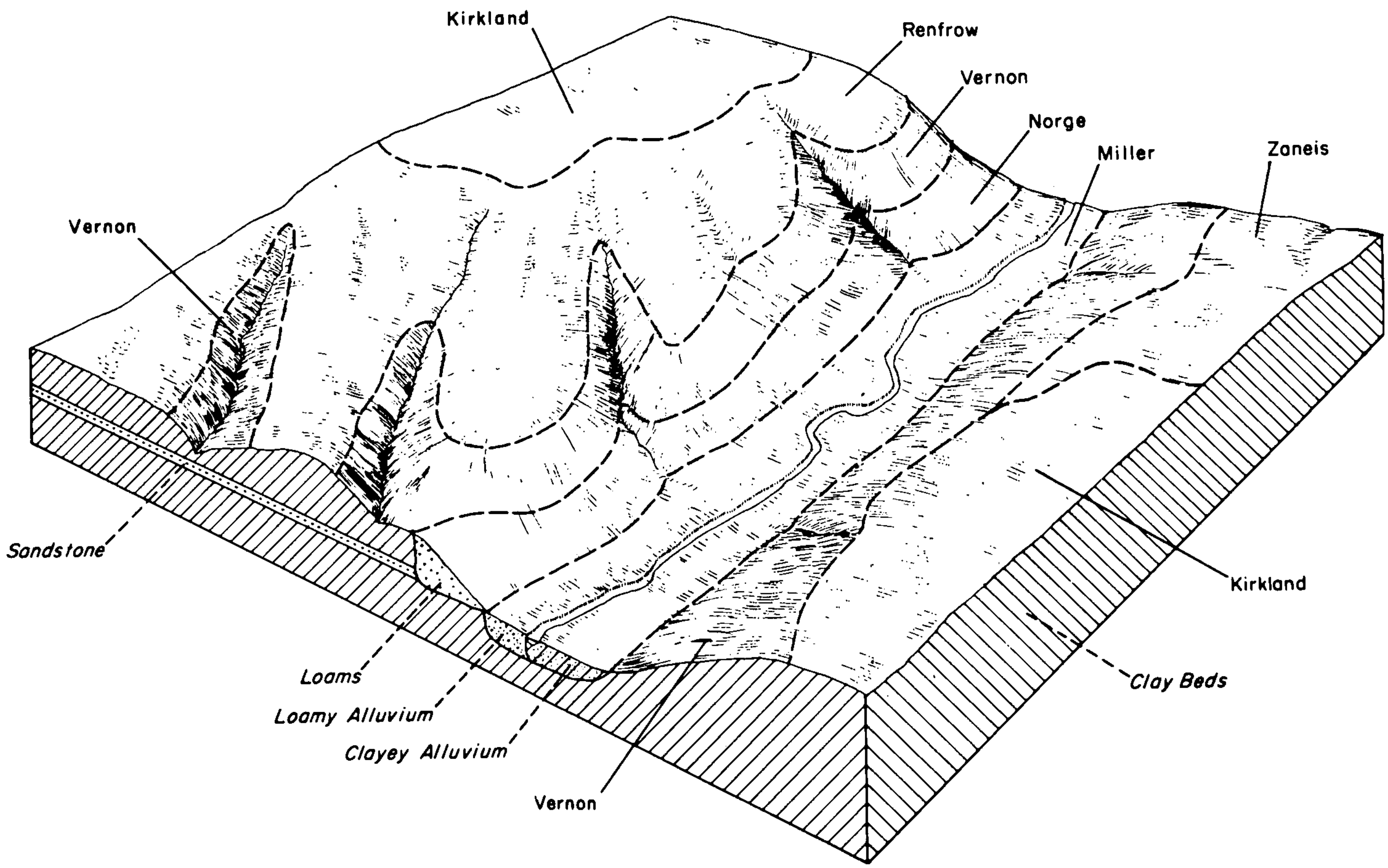


Figure 4.—**Typical pattern of soils in the Renfrow-Vernon-Kirkland association.**

by Black Bear and Red Rock Creeks and to the south by Skeleton Creek. The association covers about 23 percent of the county.

The soils formed under tall grasses from clay beds of Permian age. All of them are deep and have a silt loam surface layer. Their clayey subsoil takes up water slowly. Many of the soils are nearly level; some are in slight depressions. Though these soils take moisture slowly, they hold a large amount once they are saturated.

The soils of this association have a dark surface layer and a dark-brown or dark-gray subsoil of blocky structure. Varying amounts of lime concretions are at lower depths in these soils.

The dominant soils in this association are the Kirkland, Bethany, and Tabler (fig. 5). The Kirkland and Bethany soils are on long slopes; the Tabler are more nearly level than either the Kirkland or Bethany and in some places are in depressions that are hard to drain.

The Bethany soils have a surface layer 6 to 8 inches thicker than that of either the Kirkland or Tabler. The Tabler soils are grayer throughout than either the Kirkland or Bethany soils.

The Tabler and Kirkland soils are moderately well drained, and the Bethany soils are well drained. Surface drainage is slow for this association as a whole, and little moisture is lost through surface runoff, except during intense rains.

Maintaining structure and fertility and conserving moisture are important if these soils are to be kept in production continuously. About nine-tenths of the association is cultivated, mainly to wheat. Yields are fair to good during years of average rainfall, but somewhat high in years when rainfall is above average. Alfalfa is grown to some extent, mainly on the Bethany soils.

On this association, livestock raising is secondary to growing of small grains. Most of the livestock is grazed on rented or leased fields that have been planted to winter wheat. The few pastures in this association are in native vegetation and only 5 to 20 acres in size. Few sites are suitable for dams that impound water for livestock. Most of the ponds for livestock are excavated.

6. Drummond-Miller Association

Deep, nearly level soils of the bottom lands

This association consists of deep, nearly level soils that occur on bottom lands along Dry Salt Creek west of the town of Drummond. This association makes up about 2 percent of the county.

The Drummond soils in this association are nonarable. They are saline and in some seasons have a water table within 4 feet of the surface. Most of these areas are in native grass. Where they can be cultivated, they should be reseeded to native vegetation that has high tolerance

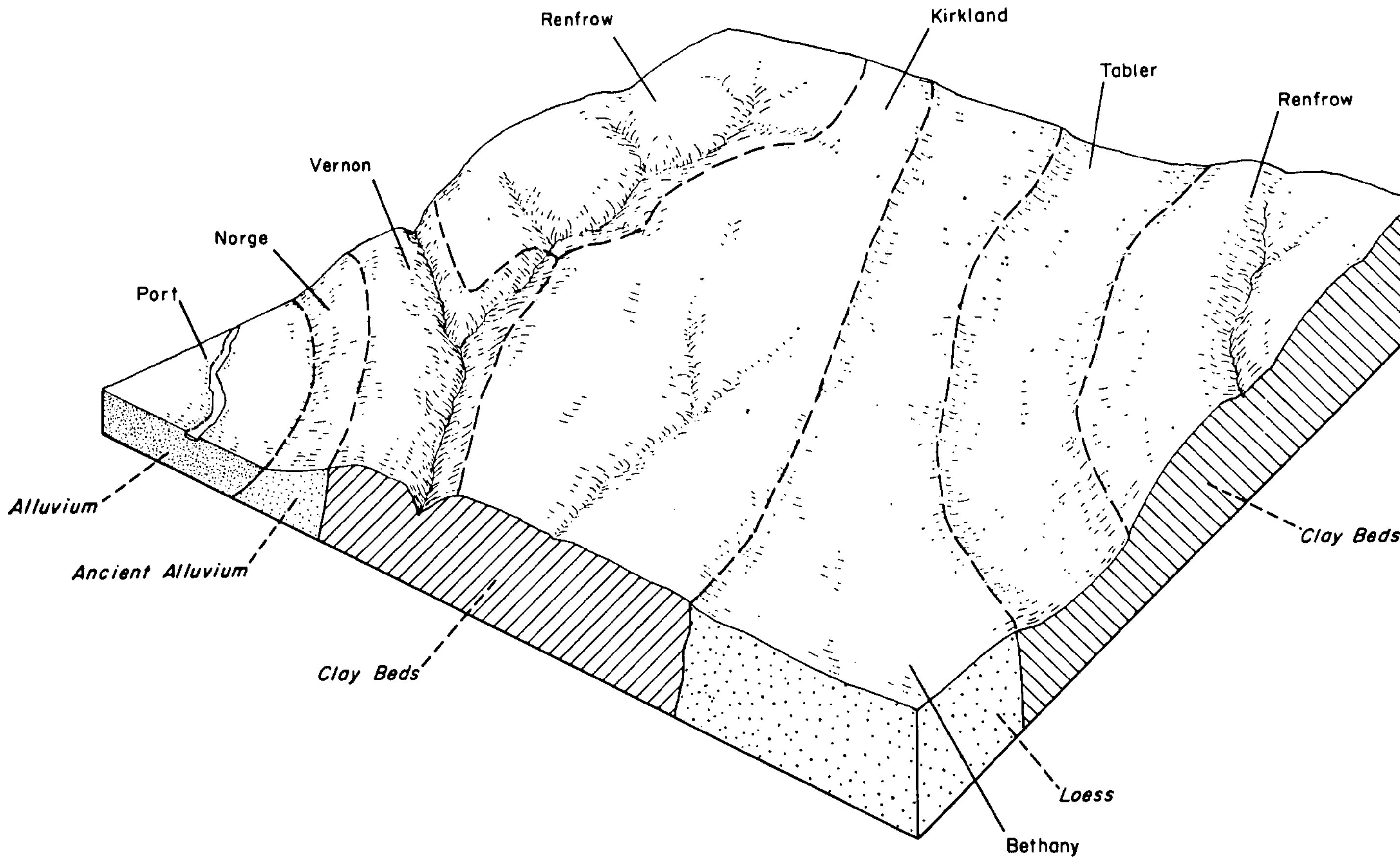


Figure 5.—**Typical pattern of soils in the Kirkland-Bethany-Tabler association.**

for salt. The original vegetation was switchgrass, prairie reedgrass, and saltgrass. Now, most areas have been overgrazed and only saltgrass is left.

The Miller soils are red, clayey, and somewhat poorly drained. They are in nearly level areas and require drainages for maximum production. Because the water table is high in some seasons, subsurface drainage is needed.

The particular interests in managing this association are maintenance of soil structure, control of salinity, and subsurface drainage.

7. Zaneis-Lucien-Vernon Association

Deep and shallow, very gently to steeply sloping soils of the uplands

This association consists of deep and shallow soils of the uplands. Most areas are gently sloping, but some are very gently sloping, and some are steep. The association covers about 1 percent of the county and occurs in the southeastern part.

The dominant soils in this association are the Zaneis, Lucien, and Vernon. The Zaneis are deep, medium-textured, well-drained soils that formed in material weathered from sandstone. They are either medium or slightly acid in the top 2 feet, and neutral below. Where they have been cultivated for a number of years, they are eroded, and conserving moisture therefore is a problem.

The Lucien soils are shallow, medium-textured, gently sloping soils of the uplands that formed in material derived from sandstone. They are well drained, but their depth over sandstone is only about 14 inches. This limits their capacity to store moisture and makes them somewhat droughty, even though they absorb moisture readily.

The Vernon are shallow and very shallow soils over shale. Those on steep nonarable uplands are very shallow and are mapped along with areas where loose rock is on the surface. Some areas of the Vernon soils are on moderately steep, excessively drained escarpments where the native vegetation is sparse and hard to maintain if grazed.

Conservation of range vegetation is the main concern. About 80 percent of this association is in native grass, and range management must be carefully applied to maintain good stands. There are many natural sites for stockwater ponds, but the soil material available for construction is limited. Minor eroded areas, once cultivated, have been reseeded to native grass. Much of this association could be used for recreation if it were managed as a habitat for wildlife.

Descriptions of the Soils

Described in this section are the soil series, or groups of similar soils, and the single soils, or mapping units, in Garfield County. The soil series are described in alphabetic order. Each series is followed by a description of the soils in that series.

An important part of each soil series is a description of the layers, or horizons, in a typical profle. All the soils in

one series are assumed to have essentially this kind of profile; minor differences, if any, are pointed out in the description of each soil. Thus, to get full information about the nature of any soil, it is necessary to read both the description of that soil and the profile description of the soil series to which the soil belongs. The descriptions of soil series in this part of the survey are generalized. Soil scientists and others may prefer the detailed technical descriptions of soil series in the section on "Classification and Morphology of Soils."

The approximate acreage and proportionate extent of the soils are shown in table 1, and their location is shown on the detailed map at the back of this soil survey. The "Guide to Mapping Units" at the back of the survey gives a list of the soils in the county, and the capability unit, range site, and woodland group into which each has been placed. Terms that may not be familiar are defined in the Glossary at the back of this soil survey and in the "Soil Survey Manual" (*5*).[1]

Bethany Series

The Bethany series consists of deep, medium-textured, nearly level soils of the uplands. These soils formed in calcareous or alkaline silts and clays in the east-central part of the county.

[1] Italic numbers in parentheses refer to Literature Cited, p. 55.

The surface layer is a dark-brown or dark grayish-brown, slightly acid, moderately permeable, friable silt loam of granular structure. The subsoil is a brown or dark-brown, mildly alkaline clay of blocky structure. It ranges from 24 to 36 inches in thickness.

The underlying substratum is a massive silty clay loam or clay loam. It is at depths ranging from 42 to 54 inches but is most frequently at a depth of 50 inches. It is somewhat more permeable and calcareous than the subsoil.

Bethany soils are associated with the Kirkland and Tabler soils, but are better drained, have a thicker surface layer, and have a transitional layer, 4 to 8 inches thick, just above the subsoil. They are darker throughout than are the Tabler soils. Bethany soils have a darker colored surface layer and are less red and permeable in the subsoil than the Pond Creek soils.

Bethany soils are well drained. Both external and internal drainage are medium. The inherent fertility of these soils is high, and their capacity to hold moisture is medium to high. They are fairly easy to work.

Bethany silt loam, 0 to 1 percent slopes (BeA).—This is one of the more desirable soils of the uplands. Some of the larger areas are immediately east of Enid. The native vegetation was a thick cover of tall grasses.

Included with this soil in mapping were minor areas of Kirkland silt loam, 0 to 1 percent slopes, and of Tabler silt loam.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Bethany silt loam, 0 to 1 percent slopes	19, 970	3. 0
Breaks-Alluvial land complex	32, 220	4. 8
Broken alluvial land	17, 402	2. 6
Carwile loam	4, 470	. 7
Drummond soils	3, 803	. 6
Eroded clayey land	12, 547	1. 9
Grant silt loam, 0 to 1 percent slopes	7, 220	1. 1
Grant silt loam, 1 to 3 percent slopes	38, 525	5. 7
Grant silt loam, 3 to 5 percent slopes	2, 059	. 3
Grant silt loam, 3 to 5 percent slopes, eroded	25, 034	3. 7
Grant-Nash silt loams, 5 to 8 percent slopes	3, 284	. 5
Grant-Nash silt loams, 5 to 8 percent slopes, eroded	9, 766	1. 4
Grant-Nash silt loams, 8 to 20 percent slopes	6, 821	1. 0
Grant-Nash silt loams, 8 to 20 percent slopes, eroded	8, 337	1. 2
Kingfisher silt loam, 1 to 3 percent slopes	6, 881	1. 0
Kingfisher silt loam, 2 to 5 percent slopes, eroded	2, 054	. 3
Kingfisher-Lucien complex, 5 to 8 percent slopes, eroded	230	(1)
Kirkland silt loam, 0 to 1 percent slopes	70, 714	10. 5
Kirkland-Renfrow silt loams, 1 to 3 percent slopes	95, 340	14. 1
Kirkland-Slickspots complex, 0 to 1 percent slopes	5, 056	. 7
Lucien very fine sandy loam, 3 to 5 percent slopes	937	. 1
Meno loamy fine sand, undulating	11, 611	1. 7
Miller clay	2, 503	. 4
Miller-Slickspots complex	2, 358	. 3
Nash silt loam, 1 to 3 percent slopes	2, 426	. 4
Nash silt loam, 3 to 5 percent slopes	1, 820	. 3
Norge loam, 1 to 3 percent slopes	5, 589	. 8
Norge loam, 3 to 5 percent slopes	960	. 1
Norge loam, 3 to 5 percent slopes, eroded	5, 990	0. 9
Norge loam, 5 to 8 percent slopes	583	(1)
Norge loam, 5 to 8 percent slopes, eroded	4, 477	. 7
Pond Creek silt loam, 0 to 1 percent slopes	26, 240	3. 9
Pond Creek silt loam, 1 to 3 percent slopes	7, 292	1. 1
Port clay loam	4, 091	. 6
Port silt loam, 0 to 1 percent slopes	26, 679	4. 0
Port silt loam, 1 to 3 percent slopes	2, 196	. 3
Pratt loamy fine sand, undulating	3, 453	. 5
Pratt loamy fine sand, hummocky	6, 593	1. 0
Pulaski fine sandy loam	2, 385	. 4
Reinach loam	5, 000	. 7
Reinach-Slickspots complex	1, 653	. 2
Renfrow clay loam, 0 to 1 percent slopes	2, 057	. 3
Renfrow clay loam, 1 to 3 percent slopes	2, 516	. 4
Renfrow silt loam, 3 to 5 percent slopes	7, 492	1. 1
Renfrow-Vernon complex, 3 to 5 percent slopes, eroded	51, 120	7. 6
Shellabarger fine sandy loam, 0 to 1 percent slopes	4, 401	. 7
Shellabarger fine sandy loam, 1 to 3 percent slopes	5, 200	. 8
Shellabarger-Carwile fine sandy loams, undulating	12, 012	1. 8
Tabler silt loam, 0 to 1 percent slopes	18, 490	2. 7
Vernon clay loam, 3 to 5 percent slopes, eroded	27, 421	4. 1
Vernon soils, 5 to 12 percent slopes	37, 834	5. 6
Vernon soils and Rock outcrop	4, 090	. 6
Weymouth-Ost loams, undulating	2, 087	. 3
Zaneis loam, 1 to 3 percent slopes	2, 179	. 3
Zaneis loam, 3 to 5 percent slopes	522	(1)
Zaneis loam, 3 to 5 percent slopes, eroded	570	(1)
Total	674, 560	100. 0

[1] Less than 0.1 percent.

234-147—67——2

Most of this Bethany soil is cultivated to winter wheat, and some to alfalfa. Though it has been cultivated for many years, it still contains a good supply of organic matter. It is well drained, nearly level, and only slightly susceptible to water erosion when cultivated. Drainageways are small and widely separated. (Capability unit I–2; Loamy Prairie range site)

Breaks-Alluvial Land Complex

Breaks-Alluvial land complex (Bk) occurs in small natural side drainageways in the prairie uplands. These drains can be classed as very young intermittent streams; they feed larger streams.

This complex has three fairly distinct parts, the side slopes, the alluvial deposits along the stream channels, and soils in the actual channels of the streams, which are exposed except during comparatively short periods when the streams are flowing. The alluvial deposits are up to 150 feet wide and highly stratified. The actual stream channels are 2 to 12 feet deep and 4 to 14 feet wide. In some places these channels have cut through the alluvial deposit and exposed the underlying red beds.

In the western half of the county the side slopes are occupied by steeply sloping nonarable Grant and Nash soils. The soils on the stream floors along these drains consist of loamy or silty mixed alluvium.

In the eastern half of the county the side slopes are dominantly occupied by the steeply sloping Vernon soils, but also by the Norge and Renfrow. Above these soils, on the bordering upland and not part of this complex, are the Kirkland, Bethany, Tabler, and Zaneis soils. The alluvial soils on the stream floors of this complex are slightly more clayey and silty than soils of this complex in the same relative position in the western part of the county.

This complex is in small, steep, frequently flooded areas where geologic erosion keeps some of the side slopes raw and unproductive. The complex is practically all in native grass, and cultivating it is not profitable. Forage yields are high on the alluvial part because the plants receive extra moisture from floods and from seepage down the slopes. (Capability unit VIe–2; Breaks in Loamy Prairie range site, and Alluvial Land in Loamy Bottom Land range site)

Broken Alluvial Land

Broken alluvial land (Br) occurs on the lowest, most frequently flooded bottom lands along larger streams. It lies below such soils as the Port, Reinach, and Miller. Soil material is removed from some locations and deposited in others each time floodwaters raise above the channels. Typical areas of this land are along Turkey Creek and Red Rock Creek where waters at flood stage have cut deep, wide, well-entrenched channels and left deposits of alluvium bordering the channels.

The surface layer ranges from a fine sandy loam to a loamy fine sand. The mixed material in the lower part varies in thickness. Slopes range from gentle to steep.

This nonarable land supports a thick stand of trees, mainly cottonwood and elm, and a mixed undergrowth that includes some shrubs and tall grasses. (Capability unit Vw–1; Loamy Bottom Land range site)

Carwile Series

In the Carwile series are deep, moderately dark soils that formed in eolian sands and sandy clays. They occur in nearly level areas or slight depressions in the uplands, mainly in the southwestern part of the county.

The surface layer is a very fine sandy loam or loam that is free of lime, very dark grayish brown, and easily worked. This layer is about 10 inches thick, is slightly acid or medium acid, and in some places has been reworked by wind and consequently is variable in texture.

The subsoil is 28 inches thick, has blocky structure, and is extremely hard when dry. It is not so clayey nor so compact in the upper 5 inches as in the lower part, which is a mottled grayish-brown clay. This lower part in some places contains free lime.

The underlying material, which is at a depth of about 38 inches, is dark grayish-brown, massive sandy clay or clay. In some locations this material contains lime concretions.

Carwile soils are somewhat poorly drained. Internal drainage is very slow, and surface drainage is slow. The subsoil is very slowly permeable. The subsoil and underlying material have high capacity to store moisture once they are saturated.

Carwile soils are more clayey, darker colored, and more poorly drained than the nearby Pratt soils, and contain more lime. Their layers are more distinct than those of the Shellabarger soils.

Carwile loam (Ca).—This soil is ponded in some places. It is in nearly level areas or slight depressions.

A fluctuating, seasonally high water table is 3 to 5 feet from the surface. Also, moisture seeps from the slightly higher, more permeable Pratt soils, which generally surround this soil.

This soil can be farmed without artificial drainage; but during years of high rainfall, planting is sometimes delayed and yields are lowered. Most areas of this soil are cultivated, mainly to small grains and grain sorghum. Maintenance of soil fertility, control of wind erosion, and drainage are the main factors to be considered in managing this soil. (Capability unit IIw–1; Loamy Prairie range site)

Drummond Series

The Drummond series is made up of deep soils that formed in loamy earths of various colors. The underlying material in most places is stratified old alluvium that washed from soils of eolian origin. These soils are in level areas, and in depressions, a few of which are 2 to 4 feet deep and up to 30 feet in diameter.

The total acreage of these soils is small. The largest area is immediately west of Drummond; smaller areas occur through the central part of the county, generally near small prairie drainageways. Eroded slickspots cover parts of the various areas.

The surface layer is a grayish-brown loam about 7 inches thick; generally it has a vesicular crust, 1/8 to 1/2 inch in thickness, that limits intake of moisture. The surface layer has weak granular structure or is massive. It ranges

from very fine sandy loam to loam in texture. In some places its depth ranges up to 15 inches.

The subsoil is either a clay loam or a light clay of weak columnar structure. Faces of the columns are coated with dark-brown, shiny clay films. This layer is brown or reddish brown and 6 to 16 inches thick. In the lower part it generally contains many white salt crystals.

The underlying material is massive, reddish-brown fine sandy loam stratified with sandy and clayey layers of variable thickness. Beginning at a depth of 22 inches, this layer ordinarily is calcareous. It is several feet thick and overlies red beds.

Drummond soils are more saline than nearby Miller or Port soils, and have a profile of more variable texture. They are not so dark as the Port soils and are less clayey than the Miller.

Drummond soils (Dr).—These soils are in nearly level areas or depressions. They are somewhat poorly drained and have a fluctuating water table 2 to 10 feet from the surface.

These soils are not suitable for cultivation. Practically all their acreage is in native grasses or has been reseeded to salt-tolerant grasses. Salts injurious to most cultivated crops may be on the surface or throughout the profile. Under good range management the dominant plants are alkali sacaton, switchgrass, and inland saltgrass. (Capability unit Vs–1; Saline Subirrigated range site)

Eroded Clayey Land

Eroded clayey land (Ec) originally consisted of soils of the Renfrow, Zaneis, Kingfisher, and Vernon series, dominantly the soils of the Vernon series. But erosion has removed all of the original surface layer and left only 2 to 6 inches of clayey subsoil over the slightly weathered shale.

This land is on side slopes along gullies. Much of it is gently to strongly sloping. Some gullies are crossable with farm machinery, but those in areas that have been cultivated a number of years are not.

Raw, shaly, underlying material is visible in many places. A few, small, shaly fragments of unweathered rock are scattered over the surface. Slickspots are numerous in some locations.

Surface runoff is rapid, and the capacity to store moisture is very low. The soil material is droughty and very slowly permeable. Cultivated areas of this land should be seeded to native grass, but revegetation is difficult. (Capability unit VIe–3; Eroded Clay range site)

Grant Series

Grant soils are deep, medium textured, and nearly level to moderately steep. They are generally rich in phosphorus and potash, and they formed in calcareous silty or loamy earths. They cover a large acreage in the western half of the county.

The surface layer is 16 inches thick and has upper and lower parts. Both are reddish-brown, moderately permeable, neutral, friable silt loam. The lower part, however, has somewhat stronger structure than the upper and contains slightly more clay, even though it is still a silt loam. Worm casts are moderately numerous in the lower part.

The subsoil is neutral to mildly alkaline and about 31 inches thick. A few weak clay films coat vertical faces of the peds. The upper 14 inches is a reddish-brown, porous, silt loam or light clay loam. The lower part is a yellowish-red heavy silt loam that grades to a red substratum of weakly plastic, weakly consolidated silt loam. The substratum contains a few, small, calcium carbonate concretions, beginning at about 55 inches.

Both the upper and lower parts of the subsoil are moderately permeable, friable when moist, slightly hard when dry, noncalcareous, and of moderate, medium granular structure. The texture of the upper part is a heavy silt loam, and that of the lower part is a light silty clay loam.

Grant soils are well drained. Both their capacity to take in and to hold moisture and their fertility are high.

Pond Creek and Nash soils occur in association with Grant soils. In the subsoil the Grant is not so fine textured as the Pond Creek, and most of the Grant is more sloping. The Grant soils are deeper and have more distinct layers than the Nash.

Grant silt loam, 0 to 1 percent slopes (GaA).—This is a nearly level, deep, medium-textured soil. Included with it in mapping were a few small areas of Pond Creek silt loam, 0 to 1 percent slopes.

Almost all of this soil is cultivated to small grains, which produce high yields. The major concerns in managing this soil are conserving moisture and maintaining soil structure. The soil is only slightly susceptible to wind and water erosion during years of normal rainfall. (Capability unit I–2; Loamy Prairie range site)

Grant silt loam, 1 to 3 percent slopes (GaB).—This is a gently sloping well-drained soil. Small areas of Pond Creek silt loam, 1 to 3 percent slopes, were included with it in mapping, and also some areas of Grant soil that have a surface layer of very fine sandy loam.

This silt loam responds well to management and is suited to nearly all the crops grown in the county. Small grains, grain sorghum, and alfalfa are the main crops. Phosphate and nitrogen are needed for optimum yields. Water erosion is the main management problem. Terraces and waterways can be constructed to control this erosion. (Capability unit IIe–2; Loamy Prairie range site)

Grant silt loam, 3 to 5 percent slopes (GaC).—This is a gently sloping slightly eroded soil. Its surface layer is not so thick as that described for the Grant series. Included with this soil in mapping were small areas of Grant silt loam, 5 to 8 percent slopes, and of Nash silt loam, 3 to 5 percent slopes.

This soil is used mainly to grow small grains. Rill and gully erosion become moderately severe if the soil is not properly managed. If it is allowed to erode, fertility declines, tillage becomes more difficult, and susceptibility to erosion further increases. Practices suitable for conserving water and protecting the soil from erosion are terracing, establishing grassed waterways, tilling on the contour, and leaving crop residues on the surface. (Capability unit IIIe–1; Loamy Prairie range site)

Grant silt loam, 3 to 5 percent slopes, eroded (GaC2).—This is a gently sloping soil crossed by a few shallow gullies that cannot be eliminated by normal tillage. Within these gullies about half of the surface layer has been lost through erosion, and in places some cultivation is being done in the subsoil. Between the gullies, rill

erosion is going on, and about 4 inches of the surface soil has been removed.

Where the shallow gullies are planted to small grains, yields are lower than on the intervening areas because runoff is excessive. Ordinarily, terraces and waterways are constructed to control runoff, and some of the gullies have been seeded to grass. Contour farming and stubble mulching are other practices that can be applied to protect the soil from further erosion. (Capability unit IIIe-2; Loamy Prairie range site)

Grant-Nash silt loams, 5 to 8 percent slopes (GnD).—On the average, 65 percent of this mapping unit is Grant silt loam, and 35 percent, Nash silt loam. In some places, however, the Nash part may be as little as 20 percent of this soil complex, or as much as 40 percent. Generally, the proportion of Nash soil is greater on the stronger slopes.

The Grant soil in this complex has a surface layer 8 to 12 inches thick, and the substratum usually occurs at a depth of 38 inches. The Nash soil has a profile about 4 inches shallower than that described for the Nash series.

This mapping unit has rapid surface runoff and medium internal drainage. Management practices needed are those that conserve moisture, maintain soil structure and fertility, and safeguard against erosion. (Capability unit IVe-1; Loamy Prairie range site)

Grant-Nash silt loams, 5 to 8 percent slopes, eroded (GnD2).—Erosion has removed 4 to 7 inches of the original dark-colored surface layer from the soils of this complex. The light-colored substratum is exposed in some places. Many areas are crossed by numerous small gullies, which are plowed in with each cultivation. Large gullies are also present. Included with this complex in mapping were small areas of Grant silt loam, 3 to 5 percent slopes, eroded.

Most of this complex is cultivated, but it is low in content of nitrogen and organic matter and requires careful management that increases cost of production over that on most of the Grant soils. Some of it should be reseeded to grass. (Capability unit IVe-2; Loamy Prairie range site)

Grant-Nash silt loams, 8 to 20 percent slopes (GnE).—This mapping unit is about 40 percent Nash silt loam and 60 percent Grant silt loam. It occurs just above Broken alluvial land in the western half of the county. The areas generally run in a north-south direction. Slopes face east or west and range from 100 to 400 feet in width.

This mapping unit is most economically used for pasture. Under good range management, the vegetation consists primarily of bluestem, indiangrass, and switchgrass. The soils of this unit are permeable, porous, and susceptible to water erosion. (Capability unit VIe-1; Loamy Prairie range site)

Grant-Nash silt loams, 8 to 20 percent slopes, eroded (GnE2).—This mapping unit consists of about 60 percent Nash and 40 percent Grant soils, which are in the western half of the county. They cover the sloping to moderately steep side slopes of drainageways that grade from 8 to 20 percent.

These soils are highly susceptible to water erosion. Generally they have eroded until the surface layer is less than 6 inches in depth. Gullies less than 3 feet deep occur at intervals of about 200 to 300 feet. Gullies more than 3 feet deep are common in the drainageways.

Pasture is the most economical land use. Under good range management, the vegetation consists of indiangrass, switchgrass, and bluestem. (Capability unit VIe-4; Loamy Prairie range site)

Kingfisher Series

Soils of the Kingfisher series formed in calcareous Permian silts, clays, and shales. They are deep, medium-textured, dark-colored, very gently to strongly sloping upland soils that formed under tall grasses.

The surface layer is a dark-brown silt loam. It is friable when moist, moderately permeable, and in most places slightly acid. Although it is ordinarily 10 inches thick, it is as much as 12 inches thick in native meadows. The structure breaks from strongly granular to weakly granular when this layer is cultivated.

The reddish-brown subsoil contains more clay than the surface layer. It is about 38 inches thick, and it grades to silty or shaly red beds. The structure of the upper 6 to 8 inches of the subsoil is not so strongly developed as the structure of the lower part, which is medium blocky. The subsoil is moderately slowly permeable, is mildly alkaline, and contains a few lime concretions.

The substratum is at a depth of about 48 inches. It is red or yellowish-red, calcareous, massive, slightly weathered shale.

Kingfisher soils occur in association with Grant and Pond Creek soils. Their subsoil is finer textured than that of the Grant but not so fine textured as that of the Renfrow. Kingfisher soils are not so droughty as the Renfrow. Though they are well drained, they are not so well drained as the Grant.

Kingfisher soils have good to somewhat excessive surface drainage. Soil erosion is slight in most places because plant cover is adequate and proper tillage and other methods of soil conservation are practiced.

Kingfisher silt loam, 1 to 3 percent slopes (KfB).—This soil covers very gently sloping areas on divides of watersheds through the central part of the county. Included with it in mapping were some areas of Grant silt loam, 1 to 3 percent slopes.

Surface runoff is medium, and the soil is well drained.

This soil is planted mostly to wheat and other small grains. In periods of normal rainfall, it is not very susceptible to erosion. But sheet erosion and a breakdown of surface soil structure are occurring where there is cultivation. Stubble mulching, terracing, and contour farming help to control erosion. (Capability unit IIe-1; Loamy Prairie range site)

Kingfisher silt loam, 2 to 5 percent slopes, eroded (KfC2).—This gently sloping soil is eroded. About 6 inches of the surface layer has been removed. Included with this soil in mapping were areas totaling about 2 percent of Renfrow-Vernon complex, 3 to 5 percent slopes, eroded, and a few slickspots. The slickspots are indicated on the map by the gumbo or scabby spot symbol.

A few small and some large gullies are present. Some small areas within the soil are severely eroded. This soil is somewhat excessively drained because it is sloping and

eroded. Surface runoff is greater than on Kingfisher silt loam, 1 to 3 percent slopes.

Because of the thin surface layer and low fertility, many areas of this soil are no longer used for crops. Some have been seeded to native grasses. Phosphate and nitrogen are needed on this soil to increase yields of small grains. (Capability unit IIIe-2; Loamy Prairie range site)

Kingfisher-Lucien complex, 5 to 8 percent slopes, eroded (KlD2).—This complex is about 70 percent Kingfisher and 30 percent Lucien soils. Included with these soils in mapping were small areas of Vernon soils.

The soils of this complex are eroded. Slickspots are numerous in some places. Rill erosion occurs between gullies. Surface drainage is somewhat excessive; internal drainage is medium. (Capability unit IVe-2; Kingfisher soil in Loamy Prairie range site, and Lucien soil in Shallow Prairie range site)

Kirkland Series

The Kirkland series consists of deep, dark-colored, nearly level to very gently sloping soils that formed in alkaline reddish clays or shales. These soils are on uplands in the eastern part of the county.

The surface layer is a dark-brown, friable, granular silt loam that is slightly acid (fig. 6). This layer is generally about 12 inches thick, but it ranges from 8 to 14 inches in thickness. The surface layer rests abruptly on the subsoil, which is a layer of dark-brown, very slowly permeable, blocky clay about 32 inches thick. The subsoil is moderately alkaline and extremely hard when dry. The substratum is a yellowish-red, massive clay that is slightly more permeable than the subsoil.

Kirkland soils are moderately well drained, but tend to be somewhat droughty in dry periods. Internal drainage is very slow, and surface drainage is slow to medium.

At the surface Kirkland soils are not so gray as the Tabler soils, and their surface layer is not so deep as that of the Bethany soils.

Kirkland silt loam, 0 to 1 percent slopes (KnA).—This soil is dark brown, friable, granular, somewhat droughty, and nearly level.

Internal drainage is slow; runoff is slow to medium.

This soil is cultivated to wheat, oats, barley and rye. Yields are high where the soil is properly managed. Proper management includes a concern for the conserva tion of moisture and the maintenance of soil fertility. (Capability unit IIs-1; Claypan Prairie range site)

Kirkland-Renfrow silt loams, 1 to 3 percent slopes (KrB).—This complex consists of about 65 percent Kirkland silt loam and 35 percent Renfrow silt loam. The stronger the slope, the greater the proportion of Renfrow silt loam in the complex. Drainageways are small and widely separated; the soils are very gently sloping.

These soils are moderately well drained but droughty. They are cultivated mostly to small grains. (Capability unit IIIe-3; Claypan Prairie range site)

Kirkland-Slickspots complex, 0 to 1 percent slopes (KsA).—From 70 to 80 percent of this complex is Kirkland soil, and 20 to 30 percent is slickspots.

The Kirkland soil in this complex is somewhat different from that described for the Kirkland series, as it has been affected by salts, which disperse, or deflocculate, the aggregates. Salt crystals and salty spots occur throughout the subsoil in various concentrations and at different depths. At a depth of about 42 inches, however, there were no salts in profiles examined.

Figure 6.—Profile of Kirkland silt loam showing a 10-inch silt loam surface layer over a clayey, blocky subsoil.

The slickspots part of this complex has a silt loam surface layer that is 2 to 4 inches thick and overlies a compact, dark-brown clay subsoil. Capillary action brings soluble salts to the surface, where they accumulate as a white crust about an eighth of an inch thick. This thin crust has a platy structure and is almost impervious because salts have destroyed soil aggregates. Rains late in spring and in summer leach the salts, but never completely remove them from the profile of the slickspots part.

Figure 7.—**Wheat on Kirkland-Slickspots complex; little or no wheat is growing on the slickspots.**

Crop yields are lower on this complex than on areas of Kirkland soils mapped separately. In pastures or meadows there is considerably more saltgrass than on the Kirkland silt loam. Growth of pasture or crops is not uniform because the slickspots are scattered among the more productive areas of Kirkland soils (fig. 7).

This complex requires more intensive management than the Kirkland soils mapped separately. (Capability unit IVs–2; Kirkland soil in Claypan Prairie range site, and Slickspots in Slickspot range site)

Lucien Series

The Lucien series consists of noncalcareous shallow soils. These soils formed under grass from red, noncalcareous, soft, fine-grained sandstone and sandy shale. They are gently sloping and are well drained internally. Moisture intake is good, but there is only 14 to 20 inches of soil available to store moisture.

The surface layer is reddish-brown very fine sandy loam 6 to 8 inches thick. This layer ranges from slightly acid to medium acid. Beneath it there is a layer of dark-red, moderately permeable very fine sandy loam that is slightly to medium acid, 8 to 10 inches thick, and of weak granular structure or single grained. The substratum consists of slightly weathered red sandstone that contains fragments of hard, unweathered sandstone in some places.

Lucien soils contain less clayey material than the associated Vernon and Zaneis soils. They are as deep as the Vernon soils, but not so deep as the Zaneis. Lucien soils are more acid throughout than the Vernon.

Lucien very fine sandy loam, 3 to 5 percent slopes (LuC).—This reddish-brown soil is shallow, friable, and granular. Included with it in mapping is a small percentage of Vernon clay loam, 3 to 5 percent slopes, eroded.

Internal drainage is good; runoff is somewhat excessive. This soil has low moisture storage capacity because it lacks depth.

Most of the soil was once cultivated to wheat, but now it is largely in grass. Forage yields are fairly high under good range management. (Capability unit IVe–6; Shallow Prairie range site)

Meno Series

In the Meno series are deep, coarse-textured, nearly level to very gently sloping, moderately well drained soils. They formed in eolian sands under tall grass vegetation. Most of these soils are on uplands in the southwestern part of the county.

The surface layer is grayish-brown, friable, easily worked loamy fine sand. It is of weak grandular structure, and its reaction is medium acid. It absorbs water readily and loses it easily by surface evaporation.

Beneath the surface layer is a layer of brown loamy fine sand that may be as much as 24 inches thick. This layer is structureless, of medium acid reaction, and rapidly permeable. There is a clear boundary between this layer and the subsoil.

The subsoil is a light brownish-gray, moderately permeable sandy clay or clay loam about 26 inches thick. The structure is moderate, medium, subangular blocky. In places this layer is mottled with yellowish-brown specks and light-gray streaks. Iron concretions are numerous at some locations.

The substratum consists of structureless sands and sandy clays that contain specks that are various shades of yellowish brown.

Meno soils are mapped close to Pratt and Carwile soils. They are more clayey in the subsoil than the Pratt but not so clayey or compact as the Carwile. Meno soils are better drained than the Carwile and not so excessively drained as the Pratt.

Meno loamy fine sand, undulating (MeB).—This sandy soil is deep, moderately coarse textured, and moderately well drained. It is nearly level to very gently sloping.

Most of this soil is cultivated to small grains and grain sorghum. Where there is cultivation, wind erosion is the main concern. Cover cropping and stubble mulching are practices applied to reduce the erosion hazard and to conserve moisture. (Capability unit IIe–3; Deep Sand range site)

Miller Series

The Miller series is made up of deep, fine-textured, fairly recent soils. These soils are on bottom lands throughout the county but are more dominant in the eastern half along the larger streams. A large area occurs immediately west of Drummond.

The Miller soils were derived mainly from materials washed from Renfrow, Vernon, and Kirkland soils of the uplands. In many fields Miller soils are in back-cut sloughs or along very small drainage channels, at slightly lower elevation than the Port soils. In many places they are 300 to 400 yards from the main stream channel and close to the strongly sloping uplands.

The surface layer is dark reddish-brown clay that is friable, very slowly permeable, and of moderate, medium, granular structure. It is mildly alkaline in some places, and in others it is calcareous. This layer is 5 to 10 inches thick.

The subsoil is very slowly permeable clay that is very hard and compact when dry. It has a weak blocky structure or is massive. This dark reddish-brown calcareous layer generally is 17 inches thick, but it ranges to 25 inches in thickness. In some places this layer is almost indistinguishable from the layer below, or it is missing.

When Miller soils are extremely dry, cracking is common in the surface layer and subsoil, because the clay material has a high shrink-swell potential. This cracking aids in internal drainage and water penetration, but it can damage plant roots.

The substratum is much like the subsoil. It has no structure. It is red in some places, instead of reddish brown, and generally is somewhat more calcareous than the subsoil.

The Miller soils are much more clayey than the Reinach and in most places are at slightly lower elevations. The Miller soils are more clayey and calcareous throughout than are the Port. Miller soils have weak gilgai, or hummocky, microrelief. They are not so well drained as the Port or Reinach soils. Their internal drainage is very slow.

Miller clay (Mr).—This is a deep, fine-textured soil in nearly level areas or slight depressions. It is somewhat poorly drained and occasionally flooded. Its capacity to hold moisture is high, once it is saturated, but saturation takes longer than in most other soils in the county. All the layers in this soil absorb water very slowly, and for this reason the soil is droughty.

Most of this soil is cultivated. Wheat is the principal crop. Water erosion is not a concern, but wind erosion starts if the soil is pulverized by too frequent cultivation. Diversion terraces or terraces are constructed in some places on adjacent uplands to catch water from slopes above. Maintenance of soil structure and conservation of moisture are needed for continued high yields. (Capability unit IIIw–1; Heavy Bottom Land range site)

Miller-Slickspots complex (Ms).—This complex consists of Miller clay and areas of saline soil that are called slickspots. The slickspots make up 10 to 30 percent of the complex, and the Miller clay, 70 to 90 percent. The soils of this complex are in nearly level areas or slight depressions.

The slickspots part has a thin, light-colored surface layer over a massive, very slowly permeable clay that is high in salts. A crust forms because salinity causes breakdown of soil structure, and the soil particles then run together. In some instances, fluctuations of a high water table in fall and early in spring are responsible for movement of salts within the soil profile of the slickspots part, and also for different concentrations at the surface.

Crop yields are good on the Miller soils of this complex, but poor on the slickspots. A crust forms on the slickspots that limits the intake of moisture. This mapping unit is suitable for native pasture that has a high tolerance for salts. (Capability unit IVs–1; Miller soil in Heavy Bottom Land range site, and Slickspots in Alkali Bottom Land range site)

Nash Series

In the Nash series are moderately deep, very gently to moderately sloping soils. These soils are on uplands in the western half of the county. They formed in calcareous silty shale or sandstone.

The surface layer is granular reddish-brown silt loam about 10 inches thick. Moisture intake in this layer is moderate. This surface layer grades to the subsoil, a yellowish-red silt loam that has granular structure. The subsoil is about 12 inches thick and is mildly alkaline. In most places it is abruptly underlain by the light-gray silty shale substratum. The depth to the substratum ranges from 20 to 36 inches.

The Nash soils are well drained. Surface drainage and internal drainage are medium. These soils are moderately permeable, and because they lack depth, have only moderate capacity for storing moisture.

The Nash soils occur with the Grant and Pond Creek soils. They are not so deep as either the Grant or the Pond Creek soils, nor are they so clayey in their subsoil as the Pond Creek soils.

Nash silt loam, 1 to 3 percent slopes (NaB).—This deep or moderately deep medium-textured soil is on very gentle slopes. Some small areas of Grant soils were included in mapping this soil.

Nash silt loam, 1 to 3 percent slopes, is well drained and has medium runoff and internal drainage. It is moderately permeable. Lack of depth limits its capacity for storing moisture.

This soil is planted to wheat and other small grains. The yields are fair to good. Conserving moisture and controlling erosion are the main concerns in managing this soil. (Capability unit IIe–2; Loamy Prairie range site)

Nash silt loam, 3 to 5 percent slopes (NaC).—This soil is on gentle slopes. Surface runoff is somewhat greater than on Nash silt loam, 1 to 3 percent slopes, yet erosion is slight except during infrequent intense rains and along small, widely separated drainageways.

The surface layer is about 8 inches thick, and the depth of the soil to the substratum ranges from 20 to 36 inches. Otherwise this soil is like that described for the Nash series.

This soil is planted to small grains. Generally, yields can be kept up by maintaining soil fertility and constructing widely spaced terraces. (Capability unit IIIe–1; Loamy Prairie range site)

Norge Series

In the Norge series are deep medium-textured soils on very gently to strongly sloping uplands. These soils occur adjacent to flood plains, mainly in the eastern half of the county, along major streams, such as Black Bear and Red Rock Creeks. They formed under grass in calcareous or alkaline old alluvium.

The surface layer is a brown loam about 10 inches thick. It is moderately permeable, slightly acid, granular, friable, and easily worked. The subsoil is a red, reddish-brown, or yellowish-red clay loam or sandy clay loam that absorbs and stores moisture readily. This layer is slightly plastic when wet and firm when moist. It is ordinarily 32 inches thick and contains a few, small, clear quartz grains and some small waterworn pebbles. The substratum is yellowish-red, structureless, friable, mildly alkaline clay loam or sandy clay loam that contains a few small calcium carbonate concretions.

In a few places the substratum consists of yellowish-red loamy fine sand mixed with waterworn gravel of small and medium size. On strong slopes Norge soils contain more gravel in the subsoil and substratum than on gentle slopes. The Norge are the only soils in the county that contain, in some locations, significant quantities of gravel of various sizes.

Norge soils are immediately above the Port and Reinach soils, which occur on flood plains. They are on uplands, where they extend 500 to 1,000 feet back from the adjoining flood plains. Norge soils are not so clayey as the nearby Renfrow and Kirkland soils. They are not so dark as the Kirkland soils, and they are on stronger slopes.

Norge loam, 1 to 3 percent slopes (NoB).—This well-drained and easily tilled soil is on very gentle slopes. Surface runoff and internal drainage are medium.

Except for a few small areas in pasture, this soil is cultivated. It responds well to management, and it is suited to nearly all the crops grown in the county. Phosphate and nitrogen are needed for optimum yields. The main concerns are conservation of moisture and control of soil erosion. Terraces and waterways can be used to control water erosion. (Capability unit IIe-1; Loamy Prairie range site)

Norge loam, 3 to 5 percent slopes (NoC).—This soil is more sloping and not so deep as Norge silt loam, 1 to 3 percent slopes. Included with this soil in mapping are small areas of Renfrow silt loam, 3 to 5 percent slopes, that do not make up more than 2 percent of the total acreage.

This soil is well drained. Internal drainage and surface runoff are both medium. There are a few short narrow drains, but erosion is none or slight.

Most of this soil is planted to wheat. Cultivating on the contour, stubble mulch tillage, and terracing to divert water to protected drainageways are effective methods for protecting the soil from erosion and for conserving moisture. (Capability unit IIIe-1; Loamy Prairie range site)

Norge loam, 3 to 5 percent slopes, eroded (NoC2).—This soil has been eroded to the extent that its surface soil is now 4 to 7 inches thick. The plow layer in many areas is a mixture of surface soil and subsoil. Included with this soil in mapping were small areas of Renfrow–Vernon complex, 3 to 5 percent slopes, eroded; these areas make up about 2 percent of the total acreage.

Internal drainage of this Norge soil is good, but surface runoff is somewhat excessive. There are a few shallow gullies, and rills are numerous. Waterways and terraces help to control erosion. (Capability unit IIIe-2; Loamy Prairie range site)

Norge loam, 5 to 8 percent slopes (NoD).—This soil is almost entirely on slopes that break from the stream terraces down to the bottom lands along the larger streams. At the foot of many slopes, it is bordered by the Breaks-Alluvial land complex.

The dark surface layer is about 8 inches thick. Layers below this one contain more iron and calcium carbonate concretions and more small pebbles than are contained in corresponding layers in the Norge soils on more gentle slopes.

Drainage is excessive. Because surface runoff is rapid, the soil is susceptible to erosion where it is cultivated and improperly managed. Establishing waterways and terraces helps to control erosion. Stubble mulch tillage can be used to conserve moisture. (Capability unit IVe-1; Loamy Prairie range site)

Norge loam, 5 to 8 percent slopes, eroded (NoD2).—This soil has eroded to the extent that the surface layer is now 4 to 6 inches thick. In many areas the plow layer is a mixture of original surface soil and subsoil. Included with this soil in mapping are small areas of Renfrow-Vernon complex, 3 to 5 percent slopes, eroded, that do not constitute more than 2 percent of the acreage.

Some areas of this soil are in permanent pasture. Where the soil is cultivated, careful management is needed to control erosion. Terraces and stabilized waterways help in this control, and stubble mulching can be used to conserve moisture. Since much of the original loamy surface layer has been lost, the content of organic matter in the present surface layer is low. Application of nitrogen increases yields of small grains. This soil is somewhat droughty because of rapid surface runoff. (Capability unit IVe-2; Loamy Prairie range site)

Ost Series

In the Ost series are deep, well-drained soils on the uplands. These soils formed in old alluvium under tall grasses on undulating to nearly level relief. They occur immediately north of Enid.

The surface layer is dark-brown friable loam of granular structure. It is about 12 inches thick and easily tilled. There is a clear boundary between this layer and the subsoil, which is moderately alkaline brown clay loam. The subsoil has subangular blocky structure, a thickness of about 24 inches, and moderately slow permeability. The substratum is a massive or structureless clay loam containing much free lime and many iron concretions. It ranges from reddish yellow to strong brown and in places has both colors in about equal amounts.

The Ost soils in Garfield County are mapped only in complex with Weymouth soils. The Ost soils are not so red at lower depths as the Weymouth, have a slightly more distinct subsoil, and are noncalcareous to a depth of about 18 inches.

Pond Creek Series

In this series are dark-brown, very fertile, well-drained soils that have a moderately to slowly permeable subsoil (fig. 8). These soils are on nearly level to very gentle slopes on uplands in the western half of the county. The larger, uniform areas are around Carrier in the northwestern part of the county.

The surface layer is a dark-brown granular silt loam 12 to 16 inches thick. This layer is of weak granular structure to the depth normally plowed, but immediately below this the structure is moderate to strong granular. The reaction of this layer is slightly acid in most places but is neutral in a few.

The subsoil is generally reddish-brown silty clay loam about 34 inches thick. The upper 10 inches has granular to weak, fine, subangular blocky structure, which is better than the strong subangular blocky structure in the

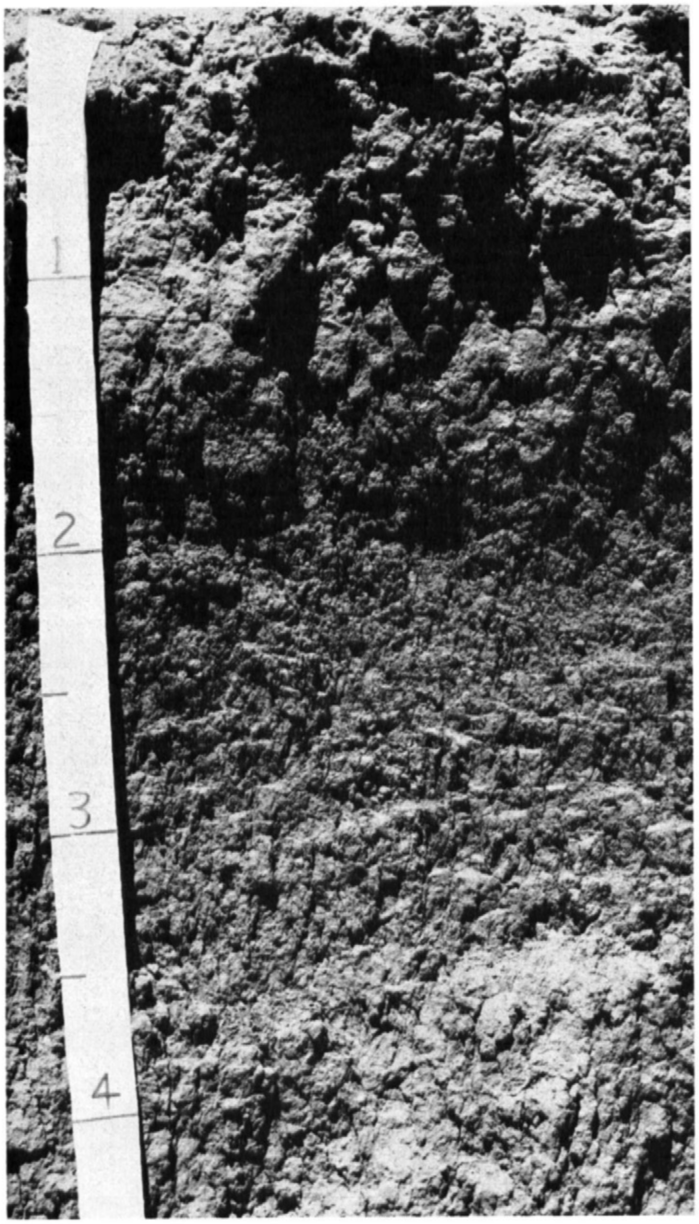


Figure 8.—**Profile of Pond Creek silt loam, 1 to 3 percent slopes.**

lower 16 inches. In some places the lower 16 inches is a light clay. The subsoil is reddish brown in most places but is light brown in some.

The substratum is silty clay loam that is massive and mildly alkaline to calcareous. This layer ranges from 46 to more than 68 inches in depth and from reddish brown to yellowish red in color. It contains some free lime in most places.

Pond Creek soils have a darker surface layer and are slightly less permeable than the Grant or Nash soils. They are much deeper than the Nash, and are calcareous, or mildly alkaline, at greater depths.

Pond Creek silt loam, 0 to 1 percent slopes (PcA).—This soil is nearly level, and its capacity to take in and store moisture is excellent. Some small areas of Grant silt loam, 0 to 1 percent slopes, were mapped with this soil.

Winter wheat is the main crop on this productive upland soil. (Capability unit I–2; Loamy Prairie range site)

Pond Creek silt loam, 1 to 3 percent slopes (PcB).—This soil is uniform and very gently sloping over large areas, but is dissected about every mile by steep drainageways. Included with this soil in mapping were areas of Grant silt loam, 1 to 3 percent slopes, that made up about 2 percent of the total acreage.

The surface layer is 2 to 4 inches thinner than that described for the Pond Creek series because of slight erosion, which occurs especially next to small drainageways.

Most of this soil is cultivated to small grains, principally wheat. Yields are high. Terraces and waterways ordinarily are used to control erosion and to conserve moisture. (Capability unit IIe–1; Loamy Prairie range site)

Port Series

The Port series is made up of deep, nearly level to very gently sloping soils in broad, fairly uniform areas on the flood plains. These flood plains border the larger creeks that have deeply entrenched channels. The Port soils also occur along the smaller unnamed drainageways, but in these locations are not nearly so uniform or so extensive.

The surface layer, either reddish-brown clay loam or dark-brown silt loam, is about 10 inches thick. This layer is slightly acid and has granular structure. The second layer ranges from 10 to 20 inches in thickness; it is friable, permeable, and neutral or mildly alkaline. The third layer starts at a depth of 20 inches and continues to 48 inches. In most places it is reddish-brown, alkaline, granular heavy silt loam. In some places, however, this layer is a dark reddish-brown, slightly plastic, calcareous silty clay loam.

Port soils are well drained and moderately fine textured or medium textured. They are relatively immature, so differences in depth, thickness, and texture of layers depend on the length of time an area was flooded and the velocity of the floodwaters.

Port soils are like the Pulaski and Reinach soils in occurring on wide stream terraces, but differ from those soils in color and texture. Port soils are darker, are heavier in texture, and are less stratified than the Pulaski. In some places Port soils have buried layers within 36 inches of the surface. The Port soils are not so frequently flooded as the Pulaski.

Port clay loam (Po).—This soil is nearly level and moderately permeable. Surface runoff and internal drainage are both medium. Flooding is unusual, except during periods of extreme rainfall.

Of the soils on bottom lands, this is one of the more desirable for farming. High yields are common (fig. 9). (Capability unit IIw–2; Loamy Bottom Land range site)

Port silt loam, 0 to 1 percent slopes (PrA).—This nearly level soil is easily tilled. Its capacity to take in and hold moisture is high. It produces high yields of small grains and alfalfa, and it is suitable for all crops commonly grown in the county. (Capability unit IIw–2; Loamy Bottom Land range site)

Port silt loam, 1 to 3 percent slopes (PrB).—This soil is less elevated than other Port soils and is more common

Figure 9.—**Excellent yield of alfalfa on Port clay loam.**

along small unnamed watercourses. It is more frequently flooded for short periods than other Port soils, but little damage results.

This soil is planted mainly to alfalfa and wheat. Yields are high. (Capability unit IIe-4; Loamy Bottom Land range site)

Pratt Series

The Pratt series is made up of brown, deep, coarse-textured soils on uplands. These are relatively immature soils that formed under grass in eolian deposits. The larger areas are in the southwestern corner of the county. Smaller areas are mapped immediately north and west of Enid.

These soils have a brown, friable loamy fine sand surface layer. This layer is about 14 inches thick, is rapidly permeable, and is slightly acid. The supply of organic matter in this layer is low after a few years of cultivation. Because the wind shifts it, this coarse-textured layer ranges from 8 to 16 inches in thickness. In some places it is a winnowed sandy loam.

The subsoil is much like the surface layer in texture and structure. It is a brown or dark-brown loamy sand that is rapidly permeable, slightly acid in reaction, and about 10 inches thick.

The substratum is reddish-yellow, rapidly permeable loamy sand of weak, granular structure that is neutral to mildy alkaline. The material in the substratum is coarse textured and has been water sorted and reworked by winds. The substratum is easily penetrated by plant roots. It overlies red beds.

Soils of the Pratt series are highly susceptible to wind erosion because they are coarse textured and low in content of organic matter, which is needed to bind soil particles together. The organic-matter content is lowered rapidly in these soils when they are cultivated. Their capacity to hold plant nutrients is low, and their inherent fertility is low, compared to that of other soils in the county.

Pratt soils are droughty. Their capacity to store moisture is low because they are coarse textured throughout the profile. Water erosion is no problem because water is absorbed rapidly and the soils are hummocky. Conserving moisture is difficult because surface evaporation can quickly draw moisture from the top 6 or 8 inches.

Pratt soils are associated with Shellabarger and Carwile soils. They do not have so clayey a subsoil as the Shellabarger. They have a lighter surface layer than the Carwile soils, and their subsoil is less clayey.

Pratt loamy fine sand, undulating (PsB).—Most of this soil is tilled. Unless a good cropping system is used, the soil will blow and drift. In unprotected fields, generally along fence lines, drifts are common.

Most of this soil is planted to grain sorghum and small grains. (Capability unit IIIe-4; Deep Sand range site)

Pratt loamy fine sand, hummocky (PtC).—This soil is on uneven, complex slopes that discourage use of heavy

farm machinery. About one-third of this soil is cultivated; the rest is in native grasses. (Capability unit IVe–5; Deep Sand range site)

Pulaski Series

In the Pulaski series are deep, light-colored soils of moderately coarse texture. They are on flood plains of large streams and prairie drainageways.

The surface layer is brown or reddish-brown fine sandy loam about 14 inches thick. This porous and moderately permeable layer has weak granular structure. Beneath it is reddish-brown fine sandy loam about 16 inches thick. This layer is easily penetrated by plant roots, is moderately permeable, and is moderately alkaline to neutral. It grades to the substratum at a depth of about 30 inches. The substratum is a yellowish-red, structureless, fine sand that contains seams of coarser material. In some locations this layer is a loamy fine sand containing small waterworn pebbles.

These soils are well drained to somewhat excessively drained and somewhat droughty because of rapid moisture intake and low capacity to store moisture.

Pulaski soils are lighter colored than Port soils and are coarser textured. Their profile is not so thick as that of the Port and has less distinct layers. Pulaski soils formed from more recent sediments than Port soils and are at a lower elevation in most places.

Pulaski fine sandy loam (Pu).—This soil is nearly level, so there is little surface runoff. Internal drainage, however, is rapid. When severe floods occur, sandy material is deposited in some places and scoured away in others.

The original vegetation was scattered elm, cottonwood, hackberry, and an undergrowth of bluestem. About 30 percent of the soil is in pasture; the rest is cultivated to small grain. (Capability unit IIw–2; Loamy Bottom Land range site)

Reinach Series

In the Reinach series are deep, nearly level, immature soils. They are on flood plains of Red Rock and Turkey Creeks and other large streams. Occasionally they are flooded for a short time early in spring, but damage to soil and crops is usually slight.

The surface layer is a reddish-brown loam of weak granular structure. It is permeable, friable, and easily worked. In some places it is moderately alkaline, but in most it is neutral. This layer is 8 inches thick in most places but ranges from 7 to 15 inches in thickness. The subsoil is a reddish-brown very fine sandy loam of weak, coarse, granular structure. This layer is porous, permeable, and easily penetrated by plant roots. The subsoil grades to the substratum, a yellowish-red, structureless, very fine sandy loam. The substratum is calcareous, permeable, and porous; it contains seams of coarser material.

Reinach soils are well drained. Their capacity to store moisture is high. Water erosion is no problem, because slope and permeability are favorable. These are among the better soils in the county, so far as tilth, or workability, is concerned. Maintenance of fertility can become a concern, however, unless careful management is practiced.

Reinach soils are not so dark as the Port and are somewhat more permeable. They are at higher elevation than the Pulaski soils and are above ordinary overflow.

Reinach loam (Rc).—This deep, loamy, nearly level soil is on bottom lands. It is well drained, and water erosion is not a problem.

Most of this soil is cultivated to alfalfa and wheat. Yields are high in years of normal rainfall. Management consists of applying vegetative practices rather than mechanical practices. Stubble mulch tillage is the exception. Maintenance of soil structure and fertility will be more important as cultivation continues. (Capability unit I–1; Loamy Bottom Land range site)

Reinach-Slickspots complex (Re).—This complex is in the same position on the bottom lands as Reinach loam. The only difference between it and Reinach loam is that slickspots are numerous. These spots range from 6 to 50 feet in diameter. The surface layer of the slickspots is light colored, high in soluble salt, and has a thin platy crust. The loamy subsoil contains various crystals of salts and has columnar structure or is massive.

About 25 percent of the complex is slickspots, 55 percent is Reinach loam, and 20 percent is intermediate between Reinach loam and slickspots. In most places the Reinach loam outside the slickspots is not saline. In some locations, however, slight to moderate concentrations of salt crystals can be seen throughout the layers of this complex.

Much of this complex is in the vicinity of the Drummond flats. Smaller areas are on Turkey Creek. They extend from the place where this creek heads in the northwestern part of the county southward to the Kingfisher County line. The soils in this complex are well drained. Both surface runoff and internal drainage are medium.

Yields of small grain are somewhat lower than on other soils of the bottom lands, and a salt-tolerant crop should be grown where possible. Barley is one of the more salt-tolerant small grains. Addition of gypsum and practice of stubble mulch tillage are helpful on the slickspots. (Capability unit IIIs–1; Reinach soil in Loamy Bottom Land range site, and Slickspots in Alkali Bottom Land range site)

Renfrow Series

Soils of the Renfrow series formed under grass vegetation in material derived from clayey red beds. They are deep, moderately fine textured to medium textured soils of the uplands (fig. 10). They are moderately well drained and are nearly level to gently sloping. Their supply of plant nutrients is fair to good.

The surface layer is about 12 inches thick. It is a layer of reddish-brown and dusky red, slightly acid clay loam or silt loam that has moderately slow permeability. This layer is not easily worked and dries out slowly after moderate rains. The granular structure is easily destroyed if this layer is cultivated too often.

The subsoil is dark-red and reddish-brown clay of coarse blocky structure. It is very plastic when wet and very hard and compact when dry. This layer is about 30 inches thick, very slowly permeable, and moderately alkaline at lower depths. It contains a few black iron and some calcium carbonate concretions.

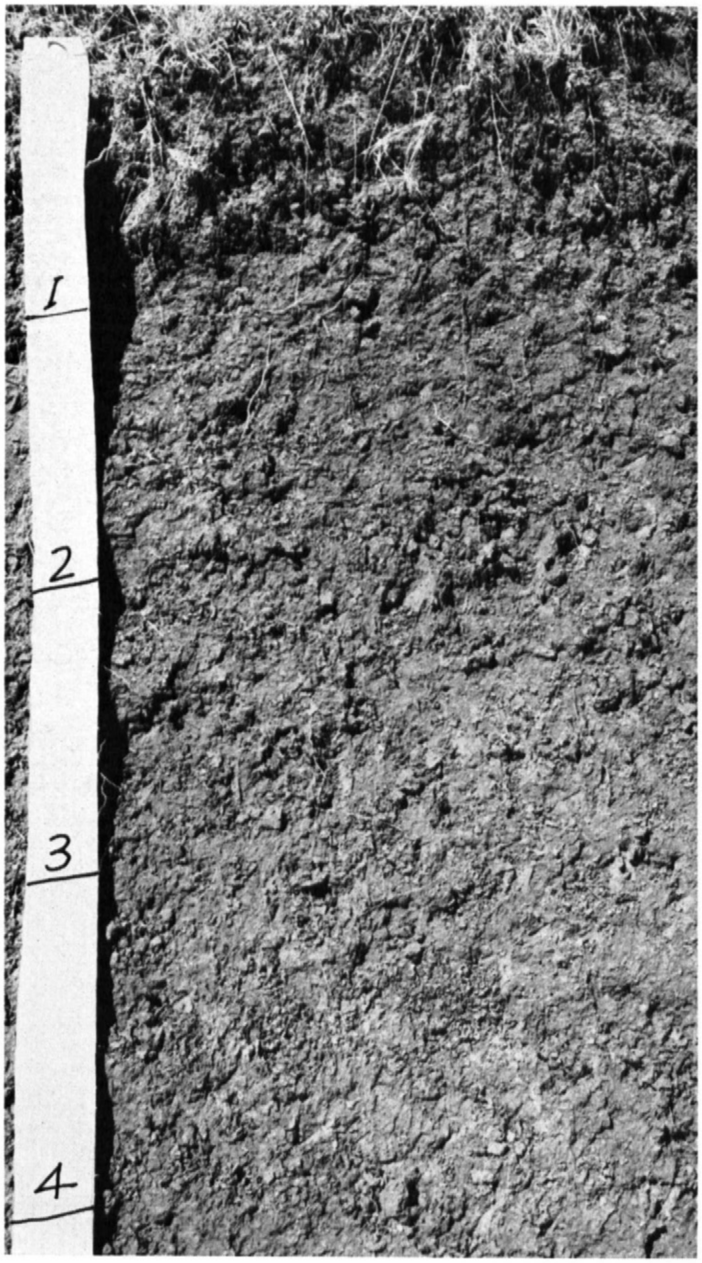


Figure 10.—**Renfrow clay loam, 0 to 1 percent slopes, a clayey soil that absorbs water slowly.**

The Renfrow soils have high capacity to store moisture once they are saturated, but they are droughty because they take moisture slowly.

Renfrow soils are not so dark as the Kirkland soils. They are colored like the Vernon, but unlike the Vernon, have a distinct subsoil and are much deeper. Cultivated Renfrow soils do not require so intensive management for control of erosion as do the Vernon soils.

Renfrow clay loam, 0 to 1 percent slopes (RfA).—This soil is nearly level. Runoff is slow unless the soil is saturated. A few areas having a silt loam surface layer were included with this soil in mapping.

In some places slight erosion has removed about 2 inches of the original surface layer. Crusting and packing of this layer is a concern where the soil has been cultivated too frequently or more than is necessary for proper seedbed preparation and control of competitive vegetation. The structure of this soil is easily broken down under excessive cultivation, and once it is destroyed, moisture intake is greatly reduced. Terraces are needed on some of the long gentle slopes of more than one-half percent. Diversion terraces can be used where needed to protect this soil against runoff from higher lying areas. Most areas of this soil are cultivated, mainly to wheat. (Capability unit IIs–1; Claypan Prairie range site)

Renfrow clay loam, 1 to 3 percent slopes (RfB).—The profile of this very gently sloping soil is 2 to 4 inches less deep than that of Renfrow clay loam, 0 to 1 percent slopes. In this soil the substratum starts at a depth of about 46 inches.

Rills are visible after rains, but they disappear after tillage. Terracing and stubble mulch tillage are generally practiced to maintain soil structure, to conserve moisture, and to control surface runoff.

Wheat is the principal crop, but other small grains are also grown. (Capability unit IIIe–3; Claypan Prairie range site)

Renfrow silt loam, 3 to 5 percent slopes (RsC).—This soil is on gentle slopes. It differs from Renfrow clay loam because it has a silt loam surface layer about 8 inches thick. Its structureless, clayey or shaly substratum is within 38 inches of the surface in many places.

Most of this soil is cultivated. It requires more intensive management than the nearly level or very gently sloping Renfrow soils. (Capability unit IVe–3; Claypan Prairie range site)

Renfrow-Vernon complex, 3 to 5 percent slopes, eroded (RvC2).—This complex is about 60 percent Renfrow soils, eroded, and 40 percent Vernon soils, eroded (fig. 11). It is gently sloping. Areas of severely eroded clayey land, on strong slopes, were included in mapping this complex. These included areas make up about 3 percent of the acreage occupied by the complex.

Surface runoff is rapid, and internal drainage is very slow. In the gullies that occur on side slopes most of the surface soil and, in some places, part of the subsoil have been removed by water erosion. Between gullies and at the heads of gullies about 4 inches of surface soil has been lost. Rills that form between gullies are removed by plowing.

The soils of this complex are marginal, and intensive management is required to maintain them and to control further erosion. Small grains are grown, but optimum yields are not achieved. (Capability unit IVe–4; Renfrow soil in Claypan Prairie range site, and Vernon in Red Clay Prairie range site)

Shellabarger Series

The Shellabarger series consists of deep, nearly level to gently undulating soils that formed in loamy, eolian deposits in the southwestern part of the county. These are well-drained soils on uplands.

The surface layer is a grayish-brown fine sandy loam of granular structure. It is about 10 inches thick and is neutral to medium acid. The subsoil is about 28 inches thick. It is a brown or strong-brown sandy clay loam that is friable, moderately permeable, and noncalcareous.

Figure 11.—**Renfrow-Vernon complex, 3 to 5 percent slopes, eroded.**

This layer has weak to moderate, fine or medium, subangular blocky structure; it is slightly plastic when wet and hard when dry. The substratum is a massive permeable loam that starts at a depth of about 38 inches in most places. It is strong brown or yellowish brown and in most places is neutral in reaction.

Shellabarger soils occur near Carwile and Pratt soils. The subsoil of the Shellabarger is neither so dark nor so clayey as that of the Carwile. The Shellabarger soils are about the same color as the Pratt but have a slightly heavier subsoil.

Shellabarger fine sandy loam, 0 to 1 percent slopes (ShA).—This soil is nearly level and well drained. Both surface runoff and internal drainage are medium.

Most of this soil is cultivated. It is suited to wheat, other dryland crops, and native grasses. Fertilization, residue management, cover cropping, and planting of close-grown crops help to control wind erosion. (Capability unit IIe-3; Sandy Prairie range site)

Shellabarger fine sandy loam, 1 to 3 percent slopes (ShB).—This is a well-drained soil. Included with it in mapping were a few small areas of Pratt soils.

This Shellabarger loam is cultivated, mostly to wheat and oats. Terraces are built to control water erosion. In some instances, however, terrace channels become filled because this soil has a sandy surface layer and because of wind erosion on the adjacent Pratt soils. Proper application of fertilizer and stubble mulch tillage are ways of decreasing wind erosion. (Capability unit IIe-3; Sandy Prairie range site)

Shellabarger-Carwile fine sandy loams, undulating (SrB).—These two soils are so intermixed that they were mapped as a complex. The complex is about 60 percent Shellabarger soil, and 40 percent Carwile soil. In some places the Shellabarger and Carwile soils have a loamy fine sand surface layer, instead of fine sandy loam.

The Carwile soil is in nearly level areas or slight depressions and is somewhat poorly drained. Drainage, where practical, would increase yields on this soil. The Shellabarger is in nearly level to slightly undulating areas and is well drained.

Close-growing crops and stubble mulch tillage reduce wind erosion on this complex. During periods of above normal rainfall, there is some crop damage on the Carwile soil. (Capability unit IIw-1; Sandy Prairie range site)

Tabler Series

The soils in the Tabler series are in nearly level areas or slight depressions on the uplands. They are deep and medium textured. For the most part, they are moderately well drained.

The surface layer is gray silt loam about 8 inches thick. It is of moderate or weak, fine, granular structure. This layer is permeable and easily penetrated by plant roots. It is medium to slightly acid. Immediately beneath the

surface layer is a transitional zone, a layer of gray, heavy silt loam about 2 to 4 inches thick. The subsoil begins abruptly at a depth of 12 inches; it is gray, clayey, and about 36 inches thick. Since the subsoil is very slowly permeable, penetration of plant roots is not nearly so easy as in the surface layer. Gray mottling, streaks or specks, or a complete gray coating on the peds are indications of poor internal drainage. The amount and degree of mottling vary from one location to another. This layer is very hard and compact when dry. The substratum is similar to the subsoil but is structureless, less mottled, and moderately alkaline to calcareous. This layer is at a depth of about 48 inches, and it contains small pebblelike concretions of lime.

Soils closely related to the Tabler soils are the Kirkland and Bethany. The Tabler have a grayer surface layer than either of these. The surface layer of the Tabler soils is slightly deeper than that of the Kirkland, but it is 4 to 6 inches thinner than that of the Bethany. The Tabler soils are not so well drained as either the Kirkland or Bethany soils.

Tabler silt loam, 0 to 1 percent slopes (TaA).—This soil is in the east-central part of the county. Large fairly uniform areas occur near Breckenridge. Included with this soil in mapping were soils of the Kirkland and Bethany series. These included soils occupy only a small percentage of the total acreage.

This soil absorbs water very slowly. Surface runoff is slow, and ponding occurs for short periods. In some places the ponding is caused by high fence rows thrown up during cultivation. Along roads ponding occurs because the ditches dug for drainage do not carry the water to large drainage channels, but instead serve as catch basins. In most places a few excavated field drains from the ponded areas can provide adequate drainage for crops grown in the county. As a whole, this soil does not require drainage.

This soil is cultivated mainly to small grains. Yields range from fair to good. (Capability unit IIs–1; Claypan Prairie range site)

Vernon Series

In the Vernon series are gently to steeply sloping, shallow and very shallow soils that are moderately fine textured and calcareous. They formed in shale of the Permian red beds, on rolling uplands, largely in the eastern half of the county. These soils support a mixture of tall and short grasses, mainly blue grama, hairy grama, and buffalograss.

The surface layer is reddish-brown clay or clay loam 5 to 10 inches thick. Where this layer is cultivated, it is generally neutral to calcareous and of weak, fine, granular structure, but where it is under native vegetation it is mildly alkaline to calcareous and of moderate, fine, granular structure.

There is a gradual transition from the surface layer to a layer of moderately alkaline, reddish-brown, weakly blocky clay about 13 inches thick. This clay contains calcium carbonate concretions in some places. It rests abruptly on red shale, which in some places is intermixed with gray, slightly weathered siltstone.

Vernon soils are like the nearby Renfrow soils in color, but are shallower and do not have a distinct subsoil. Also, the Vernon soils are calcareous to the surface in some locations, whereas the Renfrow are not.

Vernon clay loam, 3 to 5 percent slopes, eroded (VcC2).—This eroded soil has a surface layer 2 to 4 inches less deep than that described for the Vernon series. It is gently sloping, very slowly permeable, droughty, and difficult to till. Included in mapping this soil were areas of Renfrow-Vernon complex, 3 to 5 percent slopes, eroded, that make up only a small percentage of the total acreage.

This soil is shallow. Most of the moisture that falls is lost as runoff, and this makes the soil highly susceptible to water erosion. Most of the soil is cultivated. A few areas still in native vegetation are not eroded and have a deeper profile. Yields of small grains are low on this soil. (Capability unit IVe–4; Red Clay Prairie range site)

Vernon soils, 5 to 12 percent slopes (VrD).—This strongly sloping to steep soil is on short, narrow side slopes next to prairie drainageways. Much of it is along Otter and Wolf Creeks.

The surface layer is about 5 inches thick and contains some hard, unweathered fragments of shale. Below it is either the clay subsoil or soft, gray siltstone. The stronger the slope, the more likely it is that the soil lacks the clay layer.

This soil is nonarable. Forage yields are fair where a proper stocking rate is observed. (Capability unit VIe–2; Red Clay Prairie range site)

Vernon soils and Rock outcrop (Vs).—This mapping unit is made up of about 70 to 80 percent Vernon soils and 20 to 30 percent Rock outcrop. Much of this unit is in the eastern third of the county and in the northwestern part.

The Vernon soils in this mapping unit have little capacity to store moisture, are droughty, and are highly susceptible to erosion when overgrazed. They are in native grass and support only a thin stand. Some areas are used for wildlife. (Capability unit VIIs–1; Eroded Red Clay range site)

Weymouth Series

In the Weymouth series are slightly undulating to nearly level, deep, medium-textured soils of the uplands. These soils formed in calcareous old alluvium.

The surface layer is a dark-brown, moderately permeable, neutral to mildly alkaline, friable loam. It has granular structure and contains many to a few fine concretions of calcium carbonate. This layer is 10 inches thick in most places, but the range is from 8 to 12 inches.

The subsoil is a dark-brown to dark reddish-brown, moderately permeable, calcareous clay loam. It has moderate, granular structure in the upper part and moderate, subangular blocky structure in the lower part. The subsoil contains many small and some large concretions of calcium carbonate. This layer is about 22 inches thick.

The underlying material is yellowish-red clay loam that is structureless, calcareous, and moderately permeable. This layer ranges from 28 to 34 inches in depth from the surface. It contains many large and small calcium carbonate concretions and a few, fine, black iron concretions. Calcium carbonate appears to have been precipitated from ground water before these soils formed.

The Weymouth soils do not have the mottling or the compact subsoil of the nearby Carwile soils. At lower depths, Weymouth soils are more reddish than the Ost soils and differ also in being calcareous nearer the surface. Ost soils are noncalcareous to a depth of about 18 inches. The Weymouth soils in Garfield County occur only with the Ost soils.

Weymouth soils are nearly level, and surface runoff is slow. They have good internal drainage, however, and are only slightly susceptible to water erosion.

Weymouth-Ost loams, undulating (WoB).—This mapping unit is about 70 percent Weymouth soils and 30 percent Ost loams. In some places the Weymouth part is as little as 60 percent, and in others as much as 80 percent.

This is not an extensive mapping unit. Some areas are immediately north of Enid. Small grains, grain sorghum, and some alfalfa are grown. Conserving moisture and maintaining soil structure and fertility are the main practices needed for good management. (Capability unit IIe-1; Loamy Prairie range site)

Zaneis Series

In the Zaneis series are deep, very gently to gently sloping upland soils that are slightly to moderately eroded. They formed under tall grass vegetation in material weathered from slightly acid to neutral sandstone and shale of the red beds.

The surface soil is a reddish-brown, granular, slightly acid layer of loam that is friable, moderately permeable, and about 10 inches thick. The next layer is a transitional layer about 8 inches thick. It is reddish-brown, strongly granular, noncalcareous clay loam that is moderately slowly permeable. There is a gradual change to the lower subsoil, which is yellowish-red clay loam of blocky structure. This clay loam rests abruptly on the slightly weathered substratum, which is at a depth of about 47 inches.

Zaneis soils are naturally well drained. They are better drained and are not so clayey in their subsoil as the nearby Kirkland and Renfrow soils.

Zaneis loam, 1 to 3 percent slopes (ZaB).—Most of this soil is planted to small grains. Yields are fair to good.

The main concerns in managing this soil are the maintenance of soil fertility and soil structure and the conservation of moisture. Plowing depth should be varied to prevent development of a plowpan. Stubble mulch tillage helps to reduce the loss of moisture through evaporation. (Capability unit IIe-1; Loamy Prairie range site)

Zaneis loam, 3 to 5 percent slopes (ZaC).—This soil is on gentle slopes. It is well drained, and erosion is none to slight.

More than half of this soil is in native grass. If the soil is cultivated for a few years without proper treatment, erosion is moderate. Yields decrease mainly because the topsoil, which contains organic matter, is lost. The capacity to store moisture is lowered as erosion increases. Terracing, contour tillage, and cover cropping are a few of the practices used to control erosion and to conserve moisture. (Capability unit IIIe-1; Loamy Prairie range site)

Zaneis loam, 3 to 5 percent slopes, eroded (ZaC2).—This soil is on gentle slopes. Included with it in mapping were some areas of Renfrow-Vernon complex, 3 to 5 percent slopes, eroded.

Surface runoff of this Zaneis soil is rapid; internal drainage is slow; and moisture storage is low. Sheet and gully erosion are moderate. Long U-shaped gullies, crossable with farm machinery, have removed all the surface layer, and subsoil is now farmed. Rill erosion is occurring between gullies, but is almost unnoticed because the rills are removed by tillage.

Intensive treatment is needed on this soil. Terracing, contour tillage, cover cropping, stubble mulching and following a good crop rotation are measures that can be used to control erosion and to increase crop yields. Many areas have been reseeded to native vegetation. (Capability unit IIIe-2; Loamy Prairie range site)

Use and Management of the Soils

In this section are discussed management of soils for tilled crops, range pasture, woodland and windbreaks, wildlife, and engineering.

Management of Soils for Tilled Crops

The main objectives of good management in this county are conservation of moisture, control of erosion, maintenance of the supply of organic matter, and improvement or maintenance of tilth. In some places high water tables and slickspots also require attention.

A carefully chosen set of practices is the most effective way of controlling erosion on soils in this county. Suitable practices are growing of winter cover crops; managing crop residues to keep them at or near the surface of the soils; practicing minimum tillage; stripcropping; growing grass, legumes, or both in a long-term rotation with tilled crops; constructing terraces; farming on the contour; keeping waterways in sod; and applying fertilizer when conditions warrant its use.

The cropping system selected has much to do with the success of management. With a good system, the soil can be kept in good tilth and protected from erosion; and weeds, insects, and plant diseases can be controlled. Growing of high-residue crops is part of a good cropping system. Crops other than legumes can be used for this purpose. If small grains are grown and the straw is left as residue, it is frequently necessary to add nitrogen fertilizer. In dry years, the growth may not be heavy enough to require nitrogen to decompose the straw. When the growth of straw is heavy, however, the nitrogen added to decompose the straw insures against a shortage of available nitrogen the following year.

Alfalfa is generally a beneficial soil-building legume. Native grasses are excellent soil conditioners, and since they are important to the livestock raisers, can be considered an appropriate part of a long-term cropping system.

Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The soils are

classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible but unlikely major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest grouping, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I. Soils in class I have few limitations that restrict their use.

Class II. Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III. Soils have severe limitations that reduce the choice of plants, or require special conservation practices, or both.

Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V. Soils subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-4 or IIIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

Management of dryfarmed soils by capability units

In the following pages management of dryfarmed soils according to capability units is discussed. Important general characteristics, suitable uses, and effective management practices are given for the soils in the various capability units.

Although the climate of Garfield County is subhumid, all the soils can be cultivated without irrigation. As much rainfall as possible must be retained and used efficiently. In dryland farming attempts are made to prevent excessive evaporation and loss of soil through erosion, to increase infiltration, and to decrease the rate of runoff.

CAPABILITY UNIT I-1

Only one soil, Reinach loam, is in this capability unit. It is a deep, loamy, nearly level, well-drained soil on the bottom lands. Floods reach this soil only during the most intense rainfall, last only a short time, and ordinarily do not severely damage crops.

A cropping system that conserves soil and moisture is one that provides a legume 1 year in 6 and a high-residue crop 1 year in 5. Wheat or some other small grain that produces a large amount of residue can be grown continuously if all the residue is returned to the soil. When large amounts of straw are left on the soil, it is a good practice to apply nitrogen at seeding time to hasten decomposition of the straw. Changing the depth of tillage each year helps to reduce the formation of a plowpan. Tillage should be kept to a minimum to preserve soil structure.

The main concern in managing this soil is maintaining its fertility and structure. The inherent fertility of this soil is high.

CAPABILITY UNIT I-2

This unit is made up of deep, medium-textured, well-drained, nearly level soils of the Bethany, Grant, and Pond Creek series. These soils of the uplands are productive, friable, and easily tilled. Their capacity to take in and hold moisture is high.

Small grains, mostly wheat, are the principal crops grown. Under cultivation, the soils are slightly susceptible to erosion, but this can be controlled by good management. A suitable cropping system provides a soil-improving crop 1 year in 6, and a high-residue crop 1 year in 5. Wheat, oats, or barley can be grown every year if stubble mulch tillage is practiced and adequate nitrogen is applied. A winter cover crop should follow silage or other crops that leave little residue on the soils.

CAPABILITY UNIT IIe-1

In this unit are deep, well-drained, very gently sloping soils of the Weymouth, Ost, Kingfisher, Norge, Pond Creek, and Zaneis series. These are soils of the uplands. They have a medium-textured surface soil and a subsoil of clay loam, sandy clay loam, or silty clay loam. These

soils take in moisture somewhat slowly but have high capacity to store it. Plant root penetration is deep.

These soils are moderate to high in fertility, are fairly easy to till, and produce good yields of suitable crops under proper management. If slopes are terraced and drainageways are sodded, a suitable cropping system is one in which small grains follow legumes. Crop residues are needed to protect the soils. The main concerns in managing these soils are protecting them from erosion by controlling runoff and maintaining their structure and fertility.

CAPABILITY UNIT IIe-2

This unit is made up of deep or moderately deep, medium-textured soils of the Grant and Nash series. These are very gently sloping soils of the uplands that have a moderately permeable subsoil. They absorb water well, and readily release it to plants. If these soils are cultivated and not protected, they are subject to erosion.

These soils are suited to wheat, oats, barley, rye, legumes, and tame and native grasses. Where perennial vegetation has been established in drainageways, oats followed by a cover crop of mixed rye and vetch can be grown year after year without terraces.

One desirable way of controlling erosion is to use widely spaced terraces, grassed waterways, and contour farming. Where terraces are used, a legume grown in the cropping system 1 year in 5 helps to maintain soil structure and to improve workability. For the farmer who feeds livestock, a system that includes a legume has particular advantages.

With stubble mulch tillage and adequate application of nitrogen, wheat, oats, and barley can be grown every year. Stubble mulching increases storage of moisture, helps control erosion, improves soil tilth, and enables the farmer to use the available moisture more efficiently.

CAPABILITY UNIT IIe-3

These are deep, moderately coarse textured, well-drained soils of the Meno and Shellabarger series. They are nearly level, gently sloping, or undulating soils of the uplands. Their subsoil is moderately permeable.

If row crops are grown on these soils for 3 years, and are followed by small grains for 2 years, a legume should be grown for the next 2 years. If legumes are inoculated, nitrogen is added to the soils more efficiently. A winter cover crop should follow silage or other crops that leave little residue on the surface. Seedbed preparation should be delayed in spring until near the end of the critical windy season. Rows should run crosswise to the prevailing winds, wherever this is practical.

Nitrogen increases yields of most nonlegume crops and provides more residue to be returned to the soils where stubble mulching is practiced.

The main concerns in managing these soils are wind erosion, maintenance of soil fertility, and control of surface soil crusting.

CAPABILITY UNIT IIe-4

Only one soil, Port silt loam, 1 to 3 percent slopes, is in this unit. It is a deep, medium-textured, very gently sloping soil on flood plains. It is well drained and is flooded only occasionally for short periods.

A suitable cropping system is small grains for 7 years, followed by legumes for 2 years. Wheat or other crops that produce large amounts of residue can be grown continuously if all residue is returned to the soil. If silage crops or other crops that leave little residue are grown, a winter cover crop should follow each crop. Alfalfa and wheat are the principal crops grown, and yields are high.

Breaking up concentrations of water is one of the few problems in managing this soil. This can be done by constructing diversion ditches or terraces on adjacent uplands.

CAPABILITY UNIT IIw-1

In this capability unit are deep, moderately coarse and medium-textured soils of the Carwile series and the Shellabarger-Carwile complex. These soils are in nearly level to gently undulating areas or slight depressions on the uplands. Small mounds, or hummocks, make the relief uneven in some locations.

Carwile soils are ponded in some places because their clayey subsoil is very slowly permeable. They are droughty, since their subsoil impairs penetration of plant roots. Drainage is required in some areas, for optimum production.

On the Shellabarger-Carwile complex, spot drainage is not needed, because the Shellabarger soils are permeable and well drained. Water that would ordinarily collect on the Carwile part of the complex drains away laterally to the Shellabarger part.

One suitable cropping system is wheat for 4 years, and then 1 year of a legume. Another suitable system is wheat for 6 years, and then 2 years of perennial vegetation. Wheat benefits from fertilizer, and lime is not plentiful in these soils. Stubble mulch tillage reduces soil blowing, and where low-residue crops are grown, cover cropping is essential.

Management must take into account the fluctuating water table in the Carwile soil, which benefits crop growth in years of low rainfall but lowers yields in other years. Maintaining soil fertility and controlling the moderate wind erosion are necessary parts of good management. Because of their uneven topography, and the soils surrounding them, these soils offer few sites suitable for building terraces.

CAPABILITY UNIT IIw-2

These are deep, loamy, soils of the Port and Pulaski series. They are nearly level, well-drained and moderately well-drained soils on bottom lands.

A cropping system that conserves soil and moisture is a legume 1 year in 6 and a high-residue crop 1 year in 5. Wheat or other small grains that produce large amounts of residue can be grown continuously if all residue is returned to the soil. Changing the depths of tillage each year helps to reduce the formation of a plowpan. Tillage should be kept to a minimum to preserve soil structure. These soils are well suited to all crops grown in the county.

Though their inherent fertility is high, maintaining the fertility and structure of these soils is important. Flooding is the main concern. Flood-control structures have been proposed to protect these soils. Once these structures have been completed, these soils will be in land capability class I.

CAPABILITY UNIT IIs-1

These are deep, medium textured or moderately fine textured soils of the Kirkland, Renfrow, and Tabler series. They are nearly level upland soils that have a clayey, very slowly permeable subsoil. They are productive during

years of normal or above normal rainfall, but are somewhat droughty during seasons of low rainfall. The subsoil somewhat restricts intake of water and penetration of roots.

The Tabler soil in this capability unit contains some depressions that pond during rainy seasons. In some places simple drainage increases productivity of this soil.

One practice that helps to maintain fertility of the soils in this unit is that of including a legume in the cropping system once every 6 years. Grasses and legumes are both beneficial because they make the soils more open or porous and thus improve intake of water. Stubble mulch tillage is a valuable way of slowing evaporation of water from these soils, preventing crusting on the surface, and controlling wind erosion. In a few places terraces may be needed on very long slopes to break up concentrations of water and to control water erosion.

CAPABILITY UNIT IIIe-1

These deep, medium-textured, gently sloping soils are in the Grant, Nash, Norge, and Zaneis series. They are on uplands and are either not eroded or only slightly eroded.

A profitable cropping system to use with terraces and contour farming is small grains for 6 years, followed by 2 years of legumes or grasses. An alternate system is growing an oats-vetch mixture year after year. Row crops should not be grown over 2 consecutive years and should be followed by 2 years of small grains and 2 years of legumes. A winter cover crop should follow a low-residue crop such as silage. The management of crop residue is important where ensilage is grown.

A cropping system to use without terraces is 4 years of small grains, stubble mulched, followed by 4 years of legumes or grasses. Without terraces, all natural drainageways should be sodded or seeded to perennial vegetation. Tillage should be kept to a minimum to preserve soil structure and to help control wind erosion. Plow depths should be varied, so as to avoid forming a plowpan.

Important practices in soil management are controlling water erosion and slight to moderate wind erosion and maintaining soil fertility.

CAPABILITY UNIT IIIe-2

In this unit are deep, medium-textured, gently sloping soils of the Grant, Kingfisher, Norge, and Zaneis series. These soils of the uplands have moderate to moderately slow permeability. They are eroded because they have been cultivated without proper management. About 50 percent of the surface soil has been removed through water erosion. The present plow layer is partly material from the subsoil. There are some gullies that cannot be eliminated by tillage.

Wheat and other crops that produce large amounts of residue can be grown for 5 years if they are followed by legumes or grasses for 2 years. Terracing, contour tillage, and grassed waterways are essential. If terraces are not used, drainageways should be planted to perennial vegetation. Proper fertilization hastens growth of bermudagrass in these drainageways. If a crop is grown for silage or is one that produces little residue, it should be followed by a winter cover crop.

Conserving moisture, maintaining fertility, and controlling erosion are the main requirements in managing these soils.

CAPABILITY UNIT IIIe-3

In this unit are deep, very gently sloping soils of the Renfrow and Kirkland series. The surface layer is clay loam where the Renfrow soil is mapped alone, and silt loam where Kirkland and Renfrow soils are mapped in a complex. Soils of both series are slightly acid at the surface, but lime is plentiful at lower depths.

Erosion has caused widely spaced, small drainageways where the soils have been cultivated. These claypan soils are somewhat droughty because they absorb moisture very slowly. Their capacity to store moisture is high once they are saturated, but much of this moisture is held tightly by the clay particles and is not available to plants. They are somewhat difficult for roots to penetrate.

Wheat is the principal crop, but other small grains and grain sorghum are also suitable. Legumes or grasses should be planted for 2 years following each 7 consecutive years of wheat or other small grains. Terraces, contour farming, and well-established waterways are needed with this cropping system. Sweetclover and Austrian Winter peas are the legumes frequently grown. Grasses and legumes are beneficial because they keep the soils porous and allow better penetration of moisture. Waterways should be fertilized to get a good stand of bermudagrass.

Of particular importance in managing these soils are controlling surface runoff, conserving moisture, and maintaining soil structure and fertility.

CAPABILITY UNIT IIIe-4

Pratt loamy fine sand, undulating, is the only soil in this unit. It is a light-colored, deep, coarse-textured soil that has an undulating surface. The hummocks in the undulating relief vary in height and diameter, but the overall slope is less than 3 percent.

This soil of the uplands is loose, friable, and easily tilled, but it is subject to moderate to severe wind erosion. Both its inherent fertility and organic-matter content are low. The soil is unsuitable for terracing, because it is hummocky and coarse textured. It is droughty because it absorbs moisture rapidly but holds little of it for plants. Roots easily penetrate.

A cropping system that conserves soil and moisture is one that provides a legume 2 years in every 6. A crop that produces little residue needs to be followed by a cover crop. Row crops usually are not planted more than 2 consecutive years, but a rye-vetch mixture can be grown continuously. Where stripcropping is practiced, crop residue is left on the soil but is not stubble mulched. Seedbed preparation should be delayed in spring until near planting time. Emergency tillage is sometimes necessary to control wind erosion.

CAPABILITY UNIT IIIw-1

Miller clay is the only soil in this unit. It is a deep, fine-textured, somewhat poorly drained soil on bottom lands. It is on nearly level stream terraces, is moderately wet, and is flooded occasionally.

This soil is fertile but not easily tilled. It is droughty because it absorbs water slowly. A seasonally high water table modifies its normal droughtiness in some locations. Heaving occurs because the soil is clayey throughout and shrinks and swells as content of moisture changes. The soil has high capacity to store moisture, but much of this is not available to plants. Plants can reach the wilting

point while this soil still contains moisture. Crusts form on the surface, and in dry weather cracks reach to depths of 2 to 4 feet. The cracks increase intake of water for a short time after rain begins to fall.

A cropping system that protects this soil and improves plant growth is one that allows 1 year of legume for each 3 years of high-residue crops. If residue is stubble mulched, it reduces evaporation, helps to prevent crusting, and aids in minimizing fluctuations in temperature at the soil surface that can be harmful to crops. Soil-depleting crops should not be grown on this soil more than 2 consecutive years.

Controlling moderate wetness is one of the main concerns in managing this soil. Where outlets are available, a simple drainage system will allow optimum production. In some places, because of unfavorable surrounding topography, drainage to shallow ditches is all that can be accomplished. These ditches help alleviate the wetness, particularly if they have outlets to streams, creeks, or larger drainageways. Terraces are constructed in some places on nearby uplands to divert water from this soil.

CAPABILITY UNIT IIIs-1

Reinach-Slickspots complex is in this capability unit. The Reinach, a deep, nearly level soil on bottom lands, makes up 60 to 80 percent of the complex, and the rest consists of slickspots. These spots are readily noticed in cultivated fields because they are bare or support only a thin stand of the crop planted. Where the surface soil in a slickspot is cultivated, it puddles, and on drying, forms a crust that permits only slow intake of water.

If slickspots are to be cultivated, they need special treatment, including application of 3 to 5 tons of gypsum. An ideal practice is to apply 3 tons of organic material, such as barnyard manure, with the gypsum, and to defer tillage for two growing seasons. Stubble mulching can be practiced to alleviate crusting.

Row crops should not be grown on this complex for more than 2 years in succession. A suitable cropping system is small grains for not more than 4 consecutive years, and then legumes or grasses for a minimum of 2 years.

Much of this complex is cultivated. It is managed in the same manner as Reinach loam, but it needs more intensive management. It needs gypsum, organic matter, and a suitable cropping system, and it should be planted to salt-tolerant crops whenever possible. Where this complex is in native pasture, rotation grazing and control of weeds are desirable practices. If this complex is overgrazed, saltgrass crowds out the more desirable grasses.

CAPABILITY UNIT IVe-1

In this unit are deep, medium-textured, only slightly eroded soils of the Grant, Nash, and Norge series. The Grant and Nash soils are mapped together. Grant silt loam makes up about 65 percent of the complex, and Nash silt loam, about 35 percent.

The soils of this capability unit are on uplands and are moderately permeable and easily tilled. Their internal drainage is good, but surface runoff is somewhat excessive because the slopes range from 5 to 8 percent.

The principal crops are small grains, mainly wheat. For continued profitable production, the soils need to be terraced and farmed on the contour. With these practices, a suitable cropping system is small grains for 4 years and grasses or legumes for 2 years. Where there are no terraces but where perennial vegetation protects drainageways, an oats-vetch mixture can be grown year after year. Stubble mulching aids in controlling erosion and conserving moisture.

Waterways are easier to establish on these soils than on the claypan soils and do not need to be so deep nor so wide. To assure good stands of vegetation in the waterways, it is necessary to apply barnyard manure or commercial fertilizer.

The major concerns of soil management are conserving moisture, maintaining soil structure and fertility, and controlling erosion.

CAPABILITY UNIT IVe-2

These deep, medium-textured, strongly sloping, eroded soils are on uplands. They are of the Grant, Nash, Norge, Kingfisher, and Lucien series. Their internal drainage is good, but surface runoff is somewhat excessive. The Grant and Nash soils in this capability unit are mapped as a complex, as are the Kingfisher and Lucien soils. The one complex is about 65 percent Grant silt loam and 35 percent Nash soils, and the other is about 70 percent Kingfisher soils and 30 percent Lucien soils.

Some fairly wide, deep gullies occur in soils of this unit, and rill erosion is evident between the gullies. The subsoil in the gullies produces only fair yields of small grains, even in years of above-normal rainfall.

Where the soils are terraced and contour farmed, a suitable cropping system is close-growing crops for 4 years and grasses or legumes for 4 years. All the soils are stubble mulched, as this reduces evaporation and erosion and improves tilth. Nitrogen aids in decomposing the stubble and increases yields. Crops respond to phosphate.

Controlling surface runoff, conserving moisture, maintaining soil fertility, and controlling erosion are the major concerns of soil management.

CAPABILITY UNIT IVe-3

Only one soil, Renfrow silt loam, 3 to 5 percent slopes, is in this unit. It is a deep, gently sloping soil on uplands. It has a medium-textured surface layer and a very slowly permeable clayey subsoil. Most of this soil is in native grass. Because it is sloping and absorbs moisture very slowly, the surface layer of this soil is rapidly removed by water erosion where it has been cultivated.

With terraces and waterways, a cropping system that conserves moisture and controls erosion is wheat for 4 years and sweetclover for 2 years. In this system, all crop residue is fully utilized.

Without terraces, a cropping system that improves the soil is one that provides wheat or some other close-growing crops half the time and legumes half the time. This system requires stubble mulching and contour farming. Some of the legumes that increase capacity of the soil to absorb and store moisture and to improve in tilth are Austrian Winter peas and sweetclover. Soil depleting crops should not be grown more than 2 consecutive years.

Where this soil is in native grass, the medium-height grasses are dominant and easily overgrazed. The stocking rate should be carefully controlled.

CAPABILITY UNIT IVe-4

These are deep to shallow, moderately eroded soils of the Renfrow and Vernon series. They are on eroded uplands and have a very slowly permeable, clayey subsoil. They have excessive surface runoff and low capacity to store moisture. The plow layer is low in content of organic matter and not easily tilled. Slickspots are common in some locations.

Both U- and V-shaped gullies, 2 to 5 feet deep, are common. These gullies are 150 to 300 feet apart and are crossable with farm machinery. All the surface soil and part of the subsoil have been removed from the gullies.

A suitable cropping system, used with terraces and contour farming, is equal time in crops producing large amounts of residue and in perennial vegetation or legumes. Terraces are used to divert water before it reaches these soils. Generally, a complete fertilizer is applied.

It is hard to establish bermudagrass or other permanent vegetation in waterways that contain slickspots. Special treatment of the spots with 4 or 5 tons per acre of gypsum or barnyard manure will help to get the grass started.

Many acres have been reseeded to native grass, and on this reseeded land good range management is practiced. Intensive management is needed if cultivation of the soils in this unit is continued. The main concerns are conserving moisture, maintaining fertility, preventing surface crusting, and controlling erosion.

CAPABILITY UNIT IVe-5

The only soil in this unit is Pratt loamy fine sand, hummocky. It is a deep, coarse-textured soil on uplands, and it is subject to severe wind erosion. There is little surface runoff because internal drainage is rapid. The soil is droughty, and its inherent fertility is low. After a few years of cultivation, little organic matter is left in the surface layer.

A suitable cropping system consists of close-growing crops that produce large amounts of residue for 3 years, and then grasses or legumes for 2 years. Stubble mulching reduces erosion and evaporation of moisture. Commercial fertilizers are applied.

Seedbed preparation should be delayed in spring until near the end of the critical windy season. Excessive tillage should be avoided because it pulverizes the soil and allows it to blow easily. Windbreaks can be planted and stripcropping practiced. This sandy soil is not suitable for terraces. It offers few locations for farm ponds or reservoirs. Dug ponds do not hold water unless they are sealed.

About half of this soil is in native grass. Forage production is fair to good where sound management is applied. Scattered post oaks, blackjack oaks, and other woody plants grow on this soil where it is overgrazed. Sand bluestem and little bluestem are important grasses in the climax plant cover.

One of the problems in managing this soil is the uneven topography that discourages the use of heavy machinery, even though the soil is friable and easily worked. Another is the shifting or blowing sands that damage seedings of small grain or grain sorghum when the plants are young. Maintaining fertility is another concern in management.

CAPABILITY UNIT IVe-6

Lucien very fine sandy loam, 3 to 5 percent slopes, is the only soil in this unit. This shallow soil of the uplands has moderate permeability but low capacity to store moisture. It is somewhat excessively drained.

Wheat is the principal crop, but many acres are in native grass or have been reseeded to native grasses. Where small grains are grown, crop residue is returned to the soil and legumes are kept on the soil at least half of the time. Also, perennial vegetation is established in drainageways, and a complete fertilizer is ordinarily applied to maintain yields. If a crop producing little residue is grown, it is followed by a cover crop.

Terraces are constructed in some places to divert water before it reaches this soil. These empty onto pastures or immediately above farm ponds so as to supply water for livestock in years of below normal rainfall.

Management must take into account the excessive drainage of this soil and its low capacity to store moisture.

CAPABILITY UNIT IVs-1

Miller-Slickspots complex is in this capability unit. The Miller part is a deep and fine-textured soil of the bottom lands. Much of it is in nearly level areas, but some is in depressions. The soil is somewhat poorly drained. Its subsoil is very slowly permeable clay that is droughty and difficult to till.

Slickspots cover 10 to 30 percent of the surface of this complex. These spots range from 8 to 40 feet in diameter and are almost continuous in some locations. The severe surface crusting makes the slickspots almost impervious. Salts are present at different depths and in different concentrations. The seasonally high water table affects the concentration of salts and their location in the soil.

This complex can be used for small grains, legumes, and grasses. A suitable cropping system is small grains for 4 years, followed by legumes and grasses for 4 years. Where this complex is in pasture, overgrazing, or grazing when wet causes puddling and allows saltgrass to crowd out more palatable native grasses. Surface runoff increases yields.

Intensive management and special practices are required if this complex is to be farmed profitably. One of the special practices that aids in salt displacement and improves soil tilth is the addition of 5 tons per acre of gypsum to the slickspots. Tillage must then be deferred for 2 years. Minimum tillage at shallow depths is a part of good management for this soil complex.

CAPABILITY UNIT IVs-2

Kirkland-Slickspots complex, 0 to 1 percent slopes, is in this capability unit. The Kirkland part of the complex is a deep, moderately saline, claypan soil that has a medium-textured surface layer. This nearly level upland soil is droughty, allows only poor root penetration, and is difficult to till. The rest of the complex consists of slickspots, which cover 20 to 30 percent of the surface. In these spots the concentration of salts varies from place to place and in depth from the surface.

A suitable cropping system is one in which high-residue crops are grown, stubble mulch tillage is practiced, and adequate nitrogen is applied. Or, the complex can be kept in soil-improving legumes for half the time.

This complex requires careful management. In treating the slickspots, 3 to 4 tons of organic material or 3 to 5 tons of gypsum per acre is applied, and the slickspots are not tilled for two growing seasons after application. Where this complex is cropped, it is essential that tillage be kept to a minimum, that it be done at variable depths, and that it be done when the content of moisture is favorable.

Reducing salinity and surface crusting and controlling accelerated erosion in the slickspots are the major concerns in managing this complex.

CAPABILITY UNIT Vw-1

This unit consists of Broken alluvial land, a miscellaneous land type of the bottom lands. This land type is made up of deep, either gently or steeply sloping soils of a mixed medium or moderately coarse texture. This land is in the lowest, most frequently flooded areas along larger streams, such as Turkey Creek and Red Rock Creek. Deposition and scouring occur with each flooding.

This nonarable land is largely used for grazing. If brush is eradicated, weeds and woody shrubs are controlled, and other good management practices are applied, grazing is fair to good. The native grasses are big bluestem, little bluestem, western wheatgrass, and Canada wildrye.

This land type is frequently used for wildlife and recreation. Russian-olive would grow well on this soil and provide food and cover for wildlife. Post lots are fairly common. Range management for this land type is discussed under the Loamy Bottom Land range site in the section on range management.

CAPABILITY UNIT Vs-1

One mapping unit, Drummond soils, is in this capability unit. Their surface layer is of medium texture, and their subsoil of varied textures. They are in nearly level areas or slight depressions.

They are somewhat poorly drained and have a high salt content throughout. Alkali spots are numerous at the surface. A seasonally high water table is beneficial to native grasses during years of less than normal rainfall. These soils crust and puddle easily where overgrazed.

Only a few acres are cultivated, and these should be returned to grass because it is uneconomical to farm them. Mid and tall grasses, such as switchgrass, alkali sacation, and vine-mesquite, and the cool season grasses, such as Virginia wildrye and western wheatgrass, are the climax vegetation. Inland saltgrass dominates where the soils are overgrazed. Some areas once cultivated have been reseeded to a mixture of switchgrass, tall wheatgrass, alkali sacaton, and western wheatgrass.

During some seasons these soils are so wet that grazing has to be limited. Some ponded areas are used for wildlife habitat and for recreation.

CAPABILITY UNIT VIe-1

The one mapping unit in this capability group is Grant-Nash silt loams, 8 to 20 percent slopes. In this unit are deep or moderately deep, medium-textured silt loams mapped together as a soil complex. They are on sloping to moderately steep uplands that are subject to severe erosion. They are moderately permeable, but surface runoff is excessive. Where they are cultivated, it would be better to reseed to bermudagrass or to native grasses.

The soils of this complex are in the Loamy Prairie range site. When range is in the best condition, little bluestem and big bluestem are dominant and there is little woody vegetation. Many livestock ponds are constructed on these soils. A few sites containing large amounts of Nash soil material are sealed to prevent low seepage from dams. Range management practices include deferred grazing, rotation grazing, and control of noxious weeds.

CAPABILITY UNIT VIe-2

This unit consists of Breaks-Alluvial land complex, a miscellaneous land type made up of shallow Vernon soils on steep slopes and mixed local alluvium. The Vernon soils have a fine textured surface layer and a red, clayey, very slowly permeable subsoil. They are prominent in the landscape and break sharply from the associated soils. Shale is close to the surface. Internal drainage is slow; surface runoff is excessive.

The bottom lands of this land complex are narrow strips of alluvium on stream floors. They are cut in meandering patterns by shallow, dry stream beds.

Practically all of this complex is in range. Mid and tall grasses, such as hairy grama, blue grama, little bluestem, and sideoats grama, are dominant where these soils are well managed. Tall grasses are prominent on the mixed alluvium, for it receives extra moisture through flooding and some seepage from adjacent soils.

Good range management practices include proper stocking, rotation grazing, deferred grazing, and spraying or mowing for weed control. Animals graze more uniformly if salt and water are properly distributed.

The main concerns in managing this land type are protecting it from erosion and storing water.

CAPABILITY UNIT VIe-3

This unit is made up of Eroded clayey land, a land type that consists of severely eroded clayey soils of the Renfrow, Kingfisher, and Vernon series. More than one-half of this land type is made up of the gently or steeply sloping Vernon soils.

Both the fertility of these soils and their capacity to store moisture are low. Surface runoff is rapid, and internal drainage is very slow. Crusting of the surface layer is severe.

Most areas have been taken out of cultivation, fenced, and reseeded to native grasses. A mixture of hairy grama and blue grama is generally planted in a sorghum or sudan stubble. Planting in any kind of stubble or trashy surface helps prevent wind and water erosion until seedlings are established. Once plants are established, intensive range management is practiced.

This unit is in the Eroded Red Clay range site, which is discussed in the section on range management.

CAPABILITY UNIT VIe-4

This unit contains only one soil complex, Grant-Nash silt loams, 8 to 20 percent slopes, eroded. These are deep and moderately deep, medium-textured, sloping to moderately steep, eroded soils on uplands. They are moderately permeable, but their surface runoff is excessive.

Where these soils are cultivated, they should be reseeded to native grasses or to bermudagrass. These soils produce large amounts of grass if properly managed.

The soils of this mapping unit are in the Loamy Prairie

range site, which is discussed in the subsection on range management.

CAPABILITY UNIT VIIs-1

This capability unit contains one land type, Vernon soils and Rock outcrop. The soils are very shallow, and shale or sandstone outcrops in many locations. Some small and a few large stones are on the surface. Steep V-shaped channels dissect the areas of Vernon soil. In some places this land type occurs as an escarpment around a short gorge.

This land type supports only a moderate amount of vegetation. The capacity to store moisture is very low, and most of the rainfall is lost through runoff. Since the Vernon soils are droughty, they are easily overgrazed unless good range management is followed. Where the Vernon soils are overgrazed, erosion is severe. This land furnishes a good wildlife habitat. Some of it supports woody plants and other vegetation that furnish food and cover for wild turkeys, quail, and other game birds.

Estimated yields

In table 2 are estimated acre yields of principal crops grown on those soils of Garfield County suitable for cultivation; that is, the soils in capability classes I, II, III, and IV.

The yield figures given in table 2 are estimated long-time averages, not yields for any particular year. Crop failures (zero yield) were included in computing the averages. The yields serve two purposes: (1) to report, according to best information available, yields that can be expected from these soils under customary management (columns A); and (2) to indicate the response of the various soils to improved management (columns B).

The yields in columns A are those obtained under common management, which requires the following practices: (1) Using proper rates of seeding, proper dates of planting, and efficient methods of harvesting; (2) controlling weeds, insects, and diseases to insure the growth of plants; (3) using terraces and contour tillage where necessary; (4) using little or no fertilizer; and (5) using a moldboard or one-way plow.

The yields in columns B are those to be expected when management is at a high level. To keep management at a high level and obtain the yields in column B, a farmer must: (1) Use suitable cropping sequences so that tilth and supply of organic matter are maintained; (2) cultivate properly to conserve moisture in seedbed preparation; (3) use practices of wind and water erosion control where needed; (4) apply fertilizer and special soil amendments as indicated by soil tests; (5) plant suitable crop varieties and in proper amounts; (6) drain the land where necessary; (7) use terrace and contour farming where necessary; (8) use insect, weed, and plant disease controls consistently; and (9) perform all management practices at the proper time.

Management of Rangeland[2]

Native grassland occupies about 30 percent of Garfield County, or approximately 185,000 acres. Most of the pastures are less than 100 acres in size and are located near small drainageways, on steeper slopes, or in other areas not well suited to cultivation. The vegetation in pastures varies according to kind of soil and management. Most of the grasses are of the warm season type, the bluestems, gramas, and other grasses that make most of their growth during the warmer months in summer. Cool-season grasses—wildryes and wheatgrasses—also grow in some of the pastures late in fall and early in spring. Tall, deep-rooted grasses, and short, shallow-rooted grasses are represented in pastures, the dominance of one or the other depending at least partly on the management the pasture has received.

The dominant vegetation in the county originally was tall grasses, chiefly big bluestem, little bluestem, indiangrass, and switchgrass. These productive tall grasses still grow on the better managed range, but much of the county has been overgrazed and now supports the less desirable short grasses, mainly blue grama and buffalograss. Total forage yield in the county now is only one-half to two-thirds of the potential.

Livestock is a major source of income in this county, but few operating units derive income entirely from livestock. The main kind of livestock operation is that of keeping cows and raising weanling calves. Several thousand head of stocker cattle are pastured in winter on small grains. The number of cattle in the county decreased from approximately 56,800 head in 1954 to 52,300 head in 1959. In this period, however, the number of sheep increased from 15,000 to 18,700 head.

Range sites and condition classes

A range site consists of soils that support similar vegetation and are similar in depth, texture, permeability, and topography. The sites differ significantly in the kind of natural vegetation they now support; in the kinds of original, or climax, vegetation they once supported; and in the kind of management they need. Knowing the potential of the various range sites is a part of good range management. Generally, a range site made up of deep soils that hold moisture is a favorable place for growing the taller, more productive grasses. Such sites can carry more livestock than the shallow and droughty sites. Sandy lands require more intense management than the heavy clay soils.

On range sites, the original, or climax, vegetation is considered the most productive combination of plants that will maintain itself under natural range conditions. Continuous excessive grazing alters this original plant cover and lowers productivity. The livestock seek out the more palatable and nutritious grasses, and under heavy grazing these choice plants, or decreasers, are weakened and gradually eliminated. These plants are replaced by less palatable plants, or increasers. If heavy grazing continues, even these increaser plants are weakened and the site is eventually occupied by less desirable grasses and weeds, which are called invaders.

The downward trend in range vegetation is generally systematic under heavy grazing and can be expressed as range condition. Four classes of range condition are recognized, excellent, good, fair, and poor. On range in excellent condition 76 to 100 percent of the plant cover consists of the original vegetation. Range in good condition has a plant cover such that 51 to 75 percent of the vegetation is that originally on the site. On range in fair con-

[2] By HARLAND DIETZ, range conservationist, Soil Conservation Service.

TABLE 2.—*Estimated average yields per acre of principal crops under dryland farming, at two levels of management*

[Yields in columns A are those obtained under common management practices; yields in columns B are to be expected under improved management practices. Absence of yield indicates crop is not grown at the management level indicated or that the soil is unsuited to the crop. Soils and miscellaneous land types not listed in table 2 are normally not suitable for cultivation]

Soil	Wheat		Oats		Barley		Grain sorghum		Alfalfa	
	A	B	A	B	A	B	A	B	A	B
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Tons*	*Tons*
Bethany silt loam, 0 to 1 percent slopes	20	30	35	50	35	45	30	44	1.5	2.5
Carwile loam	15	23	30	40	20	30	27	39	------	------
Grant silt loam, 0 to 1 percent slopes	21	30	37	50	30	45	32	45	2.0	2.8
Grant silt loam, 1 to 3 percent slopes	19	27	32	45	25	40	28	40	1.5	2.3
Grant silt loam, 3 to 5 percent slopes	16	23	26	38	22	35	23	33	------	------
Grant silt loam, 3 to 5 percent slopes, eroded	14	20	25	35	20	33	------	------	------	------
Grant-Nash silt loams, 5 to 8 percent slopes	10	17	18	28	16	22	------	------	------	------
Grant-Nash silt loams, 5 to 8 percent slopes, eroded	9	14	18	26	15	20	------	------	------	------
Kingfisher silt loam, 1 to 3 percent slopes	18	26	30	42	24	38	25	38	1.2	2.0
Kingfisher silt loam, 2 to 5 percent slopes, eroded	13	19	22	32	18	30	------	------	------	------
Kingfisher-Lucien complex, 5 to 8 percent slopes, eroded	9	13	18	26	15	20	------	------	------	------
Kirkland silt loam, 0 to 1 percent slopes	16	24	30	45	25	40	22	30	------	------
Kirkland-Renfrow silt loams, 1 to 3 percent slopes	14	21	25	40	22	35	18	25	------	------
Kirkland-Slickspots complex, 0 to 1 percent slopes	11	18	25	35	20	30	16	22	------	------
Lucien very fine sandy loam, 3 to 5 percent slopes	9	15	16	24	14	20	------	------	------	------
Meno loamy fine sand, undulating	14	22	22	35	20	30	20	31	1.5	2.5
Miller clay	16	22	28	40	25	35	28	38	------	------
Miller-Slickspots complex	14	18	26	36	20	28	22	30	------	------
Nash silt loam, 1 to 3 percent slopes	15	22	22	32	18	25	22	32	------	------
Nash silt loam, 3 to 5 percent slopes	12	18	18	28	15	22	18	27	------	------
Norge loam, 1 to 3 percent slopes	17	26	30	45	25	40	28	42	1.5	2.5
Norge loam, 3 to 5 percent slopes	14	23	25	40	20	30	23	35	------	------
Norge loam, 3 to 5 percent slopes, eroded	12	21	22	35	18	26	------	------	------	------
Norge loam, 5 to 8 percent slopes	11	18	18	30	16	22	------	------	------	------
Norge loam, 5 to 8 percent slopes, eroded	9	15	17	26	15	20	------	------	------	------
Pond Creek silt loam, 0 to 1 percent slopes	21	31	37	50	30	45	32	45	2.0	2.8
Pond Creek silt loam, 1 to 3 percent slopes	19	27	35	45	25	40	27	39	1.5	2.3
Port clay loam	22	33	40	55	35	45	35	48	3.0	4.0
Port silt loam, 0 to 1 percent slopes	24	35	40	55	35	45	36	51	3.0	4.0
Port silt loam, 1 to 3 percent slopes	20	30	40	50	30	40	30	42	2.0	3.0
Pratt loamy fine sand, undulating	12	17	20	30	17	25	18	27	------	------
Pratt loamy fine sand, hummocky	8	13	16	25	14	20	14	22	------	------
Pulaski fine sandy loam	17	27	35	45	30	40	25	40	2.2	3.2
Reinach loam	20	31	40	50	35	45	32	47	2.5	4.0
Reinach-Slickspots complex	16	20	30	38	25	35	25	35	1.8	2.5
Renfrow clay loam, 0 to 1 percent slopes	16	24	30	42	25	35	20	28	------	------
Renfrow clay loam, 1 to 3 percent slopes	14	21	26	38	22	32	16	23	------	------
Renfrow silt loam, 3 to 5 percent slopes	11	18	25	35	20	28	------	------	------	------
Renfrow-Vernon complex, 3 to 5 percent slopes, eroded	10	15	20	30	15	20	------	------	------	------
Shellabarger fine sandy loam, 0 to 1 percent slopes	18	26	30	45	25	40	27	39	1.5	2.5
Shellabarger fine sandy loam, 1 to 3 percent slopes	15	23	25	38	22	34	23	35	1.2	2.2
Shellabarger-Carwile fine sandy loams, undulating	16	24	25	38	22	34	26	40	1.5	2.3
Tabler silt loam, 0 to 1 percent slopes	15	23	30	42	25	35	21	30	------	------
Vernon clay loam, 3 to 5 percent slopes, eroded	9	14	16	22	13	18	------	------	------	------
Weymouth-Ost loams, undulating	14	21	25	35	18	25	23	33	------	------
Zaneis loam, 1 to 3 percent slopes	16	24	30	40	20	36	22	36	------	------
Zaneis loam, 3 to 5 percent slopes	13	20	22	34	18	30	17	31	------	------
Zaneis loam, 3 to 5 percent slopes, eroded	12	19	20	30	16	24	------	------	------	------

dition, 26 to 50 percent of the vegetation is that originally on the site; and on range in poor condition, 25 percent or less of the original, or climax, vegetation remains. If range is in poor condition, the bulk of the vegetation is made up of weak increasers and invaders.

Descriptions of range sites

The soils of Garfield County have been grouped into range sites according to the types and amounts of climax vegetation produced. Each site is briefly discussed in the following paragraphs.

Estimated yield of herbage is given for each site. Herbage production depends on the nature of the site, the condition and vigor of the vegetation, and precipitation. On a given pasture, the production of herbage varies from year to year according to variations in precipitation. Successful managers allow for these variations. A stockman can protect his resources by adjusting the number of cattle to meet the capacity of the grass. Heavier stocking can be practiced during favorable rainfall periods to take advantage of the higher level of herbage production. This is usually accomplished by the addition of stocker cattle. Reduction in livestock numbers is necessary

during periods of extended drought. Many operators maintain a year's feed reserve in the form of hay and silage to cushion the effects of dry periods.

CLAYPAN PRAIRIE RANGE SITE

This site consists of level to gently sloping, upland soils that have a surface layer of silt loam or clay loam. The subsoil is a heavy clay layer that restricts the penetration of grass roots and moisture. Some buffalo wallows, or depressional areas, occur on this site.

The original vegetation consisted of big bluestem, little bluestem, switchgrass, indiangrass, and sideoats grama. On the buffalo wallows, where the claypan is usually closer to the surface, the original vegetation included much blue grama and buffalograss, and some western wheatgrass. Some inland saltgrass and other varieties of salt-tolerant vegetation grow on the slickspots that occur on this site. When this site is continuously overgrazed, the taller grasses disappear and are replaced by shorter vegetation from the depressional areas. This site recovers slowly from drought and overgrazing.

The estimated yield of air-dry herbage on this site is 4,000 pounds an acre in years of favorable moisture, and 1,800 pounds in years of unfavorable moisture.

LOAMY PRAIRIE RANGE SITE

This range site consists of deep to moderately deep, productive loams and silt loams of the uplands. These soils have a subsoil that is permeable and allows roots and moisture penetration.

The climax vegetation is tall grasses, including big bluestem, little bluestem, switchgrass, and indiangrass. If the tall grasses are overgrazed, less productive grasses such as sideoats grama, blue grama, and buffalograss increase in density.

The estimated yield of air-dry herbage on this site is 5,000 pounds an acre in years of favorable moisture, and 2,200 acres in years of unfavorable moisture.

LOAMY BOTTOM LAND RANGE SITE

In this site are deep loamy soils that allow maximum root penetration. The favorable moisture relations encourage the growth of tall grasses. This is the most productive site in the county.

When the site is in excellent condition, big bluestem, little bluestem, indiangrass, and switchgrass are dominant. Overgrazing results in an increase in western wheatgrass, vine-mesquite, sideoats grama, and blue grama and the invasion of silver bluestem, buffalograss, inland saltgrass, coralberry, ironweed, and western ragweed. Careful grazing management and control of brush are needed in many places to check the increase of coralberry (buckbrush), green ash, willow, elm, thorny honeylocust and similar woody plants.

The estimated yield of air-dry herbage on this site is 7,500 pounds an acre in years of favorable moisture, and 4,000 pounds in years of unfavorable moisture.

HEAVY BOTTOM LAND RANGE SITE

This site consists of deep, clayey soils on level bottom lands. These heavy soils along the larger creeks take water slowly. In some of the larger depressions water stands on the surface several days following a heavy rain.

Big bluestem, little bluestem, indiangrass, Canada wildrye, and an abundance of switchgrass occupy the better drained areas. Prairie cordgrass and various sedges grow well in the depressions. Sideoats grama, blue grama, buffalograss, and inland saltgrass will eventually take over if the site is overgrazed.

The estimated acre yield of air-dry herbage on this site is 5,500 pounds in years of favorable moisture, and 2,500 pounds in years of unfavorable moisture.

SALINE SUBIRRIGATED RANGE SITE

This range site occurs in the Drummond Flats area in the southwestern part of the county and consists of deep soils. The high water table is an aid to herbage production. Under good grazing management, this subirrigation contributes to high production.

Switchgrass, western wheatgrass, alkali sacaton, and inland saltgrass are the dominant grasses on soils of this site. The salts in the soils encourage growth of the more salt-tolerant plants. When the site is in excellent condition, the major grasses are prairie cordgrass, switchgrass, indiangrass, sand bluestem, and little bluestem. Excessive grazing results in a gradual increase in alkali sacaton and inland saltgrass.

The estimated yield of air-dry herbage on this site is 6,500 pounds in years of favorable moisture, and 5,000 pounds in years of unfavorable moisture.

DEEP SAND RANGE SITE

This site consists of deep sands in the western part of the county. These sands take water rapidly, so there is little or no runoff. When the site is in excellent condition, deep-rooted tall grasses, including sand bluestem, little bluestem, indiangrass, switchgrass, and sand lovegrass, are dominant. If the grass cover is thinned by heavy grazing, skunkbush, sand plum, and other woody plants gradually increase. Though this is primarily a prairie site in the southern part of the county, it supports post oak and blackjack oak, which increase if the range is not well managed.

The estimated acre yield of air-dry herbage on this site is 4,500 pounds in years of favorable moisture, and 2,000 pounds in years of unfavorable moisture.

SANDY PRAIRIE RANGE SITE

This site is made up of moderately coarse textured soils on level to very gently sloping uplands in the western half of the county. The soils take water well, and their sandy clay subsoil has the ability to hold moisture for plants. If this site is kept in good range condition, it is productive of sand bluestem, indiangrass, switchgrass, and little bluestem. Blue grama, sideoats grama, and Texas bluegrass increase if this site is overused. Areas that are overgrazed or fields no longer cultivated are invaded by mat sandbur, sand dropseed, and red lovegrass.

The estimated acre yield of air-dry herbage on this site is 5,000 pounds in years of favorable moisture, and 2,000 pounds in years of unfavorable moisture.

SHALLOW PRAIRIE RANGE SITE

This site is on rolling uplands and gentle slopes in the southeastern part of the county. Sandrock, at a depth of 10 to 20 inches, restricts penetration of moisture and limits root development and herbage production.

When the site is in excellent condition, the vegetation is mainly little bluestem, big bluestem, switchgrass, and indiangrass. Overgrazing results in an increase of blue grama, sideoats grama, Texas bluegrass, and Scribner panicum. If overgrazing is prolonged, western ragweed, Baldwin ironweed, annual three-awn, and other weeds invade the site.

The estimated yield of air-dry herbage on this site is 3,000 pounds in years of favorable moisture, and 1,500 pounds in years of unfavorable moisture.

ALKALI BOTTOM LAND RANGE SITE

The soils of this site are somewhat poorly drained loams and clays that contain large accumulations of alkali. They are on level bottom lands adjacent to the larger streams. The largest area is along Turkey Creek in the southwestern part of the county.

During periods of favorable rainfall, the water table in this site occasionally rises to a level where it subirrigates the soils and encourages moderate production of herbage. During periods of unfavorable moisture, growth of herbage is scant because the site is extremely droughty.

The climax vegetation consists of switchgrass, western wheatgrass, Canada wildrye, and Virginia wildrye. Continuous overgrazing causes a gradual decrease in these grasses and an increase of inland saltgrass, alkali sacaton, and meadow dropseed.

The estimated acre yield of air-dry herbage on this site is 4,000 pounds in years of favorable moisture, and 1,800 pounds in years of unfavorable moisture.

RED CLAY PRAIRIE SITE

This site is made up of red clay soils on gently sloping uplands to short steep breaks. The soils are underbedded with shale, which is exposed in some places. These soils are droughty and difficult to manage. Little bluestem, the principal climax grass, decreases under improper grazing, and sideoats grama, blue grama, and buffalograss increase. Continued overgrazing causes a decrease in plant cover that results in excessive runoff and erosion on the steeper slopes.

The estimated acre yield of air-dry herbage on this site is 2,500 pounds in years of favorable moisture and 1,200 pounds in years of unfavorable moisture.

ERODED RED CLAY RANGE SITE

This site produces limited herbage and requires management that controls erosion. The better grasses on this site are little bluestem, sideoats grama, hairy grama, and western wheatgrass. Continued heavy grazing causes a striking reduction in grass cover and an increase in bare soil.

The estimated yield of air-dry herbage on this site is 800 pounds in years of favorable moisture, and 500 pounds in years of unfavorable moisture.

ERODED CLAY RANGE SITE

This site is made up of Eroded clayey land which was once cultivated. Much of the surface soil has washed away because the site has been severely eroded by water. Gullies are common. Additional erosion can be prevented in many places by seeding and establishing adapted native grasses.

Tall grasses similar to those on the Claypan Prairie range site were the original vegetation on this site. Since cultivation the vegetation consists primarily of silver bluestem, meadow dropseed, windmillgrass, and annual three-awn.

The estimated acre yield of herbage on this site is 1,000 pounds in favorable years, and 400 pounds in unfavorable years.

SLICKSPOT RANGE SITE

This site consists of deep soils on nearly level uplands. A blocky clay layer that contains some alkali occurs at depths of 2 to 6 inches. This layer restricts the penetration of roots and moisture and thus impairs productivity of the site. Much of this site is interspersed with the Claypan Prairie site in the south-central part of the county.

When this site is in excellent condition, short grasses, principally blue grama, are dominant. A few plants of switchgrass, little bluestem, big bluestem, and tall dropseed are scattered over the site. When the site is in poor condition, the vegetation is made up of invaders such as fall switchgrass, old-field three-awn, western ragweed, and pricklypear cactus.

Management of Woodland for Windbreaks and Post Lots [3]

Originally native woodlands occupied much of the loamy flood plain along the larger streams, including that along Black Bear, Red Rock, Turkey, and Skeleton Creeks. Now, about 80 percent of the woodland has been cleared and is under intense agricultural use. The trees that remain grow in narrow fringes along the creeks or in a few larger areas on the flood plains. Trees also grow intermittently along Hackberry, Otter, Wolf, and Bitter Creeks, and along the tributaries of these smaller streams.

The most common kinds of trees are American elm, hackberry, cottonwood, willow, chittamwood, and several species of oak. Little use is made of any of these. Some cottonwood is cut for making boxes, and occasionally elm and hackberry are used in constructing small bridges. Some trees are cut for temporary fencing or for emergency fence repair.

Areas on the deep sandy uplands in the southwestern part and smaller areas in the western half of the county, none of which have been cleared for cultivation, support blackjack oak and post oak. These stands are mainly blackjack oak because the post oak has been cut and the stands have not been managed after harvest.

The soils of Garfield County that are suitable for windbreaks, post lots, and woodland have been placed in four suitability groups, as shown in the "Guide to Mapping Units" at the back of this survey. Following are descriptions of the four groups.

WOODLAND SUITABILITY GROUP 1

In this woodland suitability group are deep, nearly level to gently sloping soils of the uplands and bottom lands. The capacity of these soils for storing moisture is high. They have slow surface runoff and are well drained.

The soils of this group are good to excellent for growing farmstead windbreaks and for post lots. The exception is

[3] By HERBERT R. WELLS, woodland conservationist, Soil Conservation Service.

the Carwile soil in the Shellabarger-Carwile fine sandy loams complex. The Carwile soil rates only fair for windbreaks, and it is not well suited as a post lot.

Tall trees suitable for windbreaks are Siberian elm, cottonwood, and sycamore. The elms grow best in the loams and fine sandy loams and may reach a height of 75 feet in 20 years. Cottonwood and sycamore prefer the sandier soils, and they grow well in soils that have a high water table. Cottonwoods are capable of reaching a height of 85 to 90 feet in 20 years or less, but the sycamore rarely exceeds a height of 75 feet in the same period.

Russian mulberry is of intermediate height and serves as an understory to the cottonwood and sycamore trees. If closely spaced, 4 feet in the row, mulberry makes an excellent shrub.

Among the evergreens, Austrian and ponderosa pine, eastern redcedar, and some strains of the seedling (nongrafted) form of Chinese arborvitae are suitable as tall trees in windbreaks, or as the shrub row with other tall trees in a windbreak. Austrian and ponderosa pine usually are not more than 25 to 30 feet high at the age of 20 years. The arborvitae reaches 30 to 35 feet in a 20-year period.

Common species suitable for posts that do well on these soils are black locust, catalpa, and Osage-orange. The Osage-orange is the best suited of the three on the heavier soils of this group, such as the Port clay. All three of these species average at least a six-post tree in 20 years, but they give a higher return if they are selectively cut when 8 to 12 years of age, and if the sprouts are then managed for sustained yield.

WOODLAND SUITABILITY GROUP 2

In this woodland suitability group are deep, medium and coarse textured soils that are gently sloping to moderately sloping. They are generally well drained, but some soils are somewhat poorly drained.

The soils of this group are fair or good as sites for farmstead windbreaks and post lots. The exceptions are the parts of the Reinach complex that are slickspots, Breaks-Alluvial land complex, and Broken alluvial land. The Reinach-Slickspots areas generally are unfavorable for trees, but they can support Siberian elm and tamarisk of sufficient height and vigor for farmstead windbreaks. The two mapping units that contain alluvial land are in odd areas suitable for good post lots, but their location makes them unsuitable as sites for windbreaks.

The soils of this group differ from those of group 1 mainly in having less desirable moisture relationships in the subsoil. Suitable tall trees are Siberian elm, cottonwood, and sycamore. In the first 20 years these tall trees average 10 to 20 feet less growth than on soils of group 1. Trees of intermediate height, such as Russian mulberry, ponderosa pine, and eastern redcedar, make 5 to 10 percent less growth in 20 years than they do on soils of group 1. Essentially the same is true for black locust, catalpa, and Osage-orange, the species grown for posts.

WOODLAND SUITABILITY GROUP 3

In this woodland suitability group are shallow moderately deep, and deep soils that are nearly level to sloping. They are medium textured and range from permeable to very slowly permeable. Surface runoff is slight to excessive.

These soils are poor to fair for growing trees. Their limitations make them generally unsuitable as sites for field windbreaks or post-lot plantings. Farmstead windbreaks are practical where no great height is needed and where the trees can be given water from the farm supply during droughty periods.

Siberian elm is the best adapted tall tree for these soils. This elm seldom exceeds 40 to 45 feet in height in 20 years, but its rate of growth is rapid during the first several years, and it provides early protection to the farmstead. Russian mulberry also grows quite rapidly in early life, but its height averages only 30 to 35 feet in 20 years.

Eastern redcedar and Chinese arborvitae are also suitable for these soils. After 20 years they are the most valuable trees in a windbreak because of their evergreen foliage and long life, but their early rate of growth is slow and they will average but 20 to 25 feet in the first 20 years. Austrian and ponderosa pine are also adapted but are even slower in reaching an effective height.

WOODLAND SUITABILITY GROUP 4

The soils in this woodland suitability group range from shallow to deep, from nearly level to steep, and from slightly acid to strongly saline. They range from noneroded to severely eroded. They occur both on bottom lands and uplands.

These soils are not suitable for tree plantings or for woodland, mainly because of salinity, erosion, and shallowness.

Wildlife [4]

The wildlife habitats of Garfield County are mainly in those areas not intensively cultivated, dominantly on the steeper parts of the prairie uplands and in the wooded areas on the bottom lands. A small acreage of wetland habitat is in the southwestern part of the county, on the very slowly permeable Drummond and Miller soils. In the southwestern and northwestern parts of the county, Pratt, Shellabarger, and Carwile soils are suitable habitat for several kinds of wildlife.

Soils intensively cultivated to alfalfa, grain sorghum, and small grains are not available as a habitat. Among the soils of this kind are the Kirkland, Bethany, Tabler, Renfrow, Vernon, Grant, and Pond Creek soils of the uplands. The Port, Reinach, and Pulaski soils on the bottom lands are also in this group.

KINDS OF WILDLIFE: Bobwhite quail, mourning doves, fox squirrel, cottontail rabbits, and jackrabbits are the most common wildlife in this county. During migration, some waterfowl stop to feed on waste grain or the green fall-sown small grains, and to rest on the farm ponds. Vegetation in or bordering ponds provides food for migrating ducks.

Song birds of many kinds are numerous where trees and shrubs provide food and cover along streams. Some wild turkeys have been successfully stocked in wooded ravines, and these are multiplying. Mourning doves are numerous on the uplands, particularly late in summer. They are then attracted by waste grain in the fields and by grain that falls along roads during transport.

[4] By JEROME F. SYKORA, biologist, Soil Conservation Service.

The furbearers in this county are the coyote, raccoon, opossum, skunk, muskrat, mink, and bobcat. Predatory birds, hawks and owls, are prevalent along streams and in wooded areas. The only large game animal, the white-tailed deer, are few in number and are confined to the southwestern part of the county.

NATURAL FOOD AND COVER: Success in maintaining wildlife populations depends to considerable extent on the food and cover naturally available. Wooded drainageways and streams provide fair to good natural cover for quail, turkeys, squirrel, and cottontail rabbits. Vegetation growing along fence rows or county roads is not good habitat for turkeys and squirrel, but is satisfactory for quail and rabbits, and provides them travel lanes to other areas offering food and cover.

A site that offers good cover for quail, and also a good food supply, produces more birds because the eggs and young birds are not so much exposed to snakes, rats, raccoons, skunks, and other predators.

Plants that furnish food for quail are ragweed, sunflower, pokeweed, foxtail, crotons, johnsongrass, dropseeds, paspalums, native legumes, switchgrass, and indiangrass.

Woody plants in the county that provide food for wildlife are elm, chinaberry, hackberry, cottonwood, sumac, coffeetree, chittamwood, blackhaw, dogwood, ash, oak, Osage-orange, pecan, plum, black locust, and mulberry. Deer are among many kinds of wildlife that benefit from woody cover and the browse it provides. The more heavily wooded areas in the southwestern part of the county provide fair to good habitat for deer.

FISH: The large streams in this county contain channel catfish, flatheaded catfish, bullheads, black bass, crappie, carp, buffalo fish, and many kinds of small sunfish. The farm ponds are usually stocked with bass, bluegill, and channel catfish. Approximately 400 farm ponds have been built in the county, but the yield of fish is low because suspended fine clay particles keep most of the ponds turbid. The ponds built on Renfrow, Kirkland and Vernon soils usually are so turbid that they support no fish other than bullheads. The Pratt, Shellabarger, and Carwile soils are ordinarily not suitable sites for ponds.

Of the fish available for stocking ponds, the channel catfish is most tolerant of turbid water and should be stocked alone in the more turbid ponds, as these do not support bass and bluegill.

Technical assistance on stocking of farm ponds, or on maintaining or improving wildlife habitats, can be obtained from the State Wildlife Conservation Department, the U.S. Fish and Wildlife Service, wildlife specialists of the Extension Service, and biologists of the Soil Conservation Service.

Use of Soils in Engineering

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to the engineer are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, grain size, plasticity, and pH. Topography and depth to water table and bedrock are also important.

Information in this survey can be used to—

1. Make studies of soil and land use that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils that will help in planning agricultural drainage systems, farm ponds, irrigation systems, and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway, airport, pipeline, and cable locations and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel and other construction materials.
5. Correlate performance of engineering structures with soil mapping units, and thus develop information useful in designing and maintaining the structures.
6. Determine suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs for the purpose of making maps and reports that will be more useful to engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

It should be emphasized, however, that the engineering interpretations made in this survey may not eliminate the need for sampling and testing at the site of a specific engineering work involving heavy loads or a site where the excavations are deeper than the depth of soil layers here reported. Even in these situations, however, the soil map and the interpretations in this survey are useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Some of the terms used by soil scientists may not be familiar to the engineers, and some commonly used words have special meanings in soil science. Most of these terms are defined in the Glossary at the back of this survey.

Most of the information in this section is in tables 3, 4, and 5, but additional information useful to engineers can be found in other sections of this survey, particularly "Descriptions of the Soils" and "Classification and Morphology of Soils."

Engineering classification systems

Most highway engineers classify soil materials according to the AASHO system (*1*). In this system soils are placed in seven basic groups, designated A–1 through A–7. In group A–1 are gravelly soils of high bearing capacity, or the best soils for road subgrade, and in group A–7 are the poorest soils, clays that have low strength when wet. Groups A–1, A–2, and A–7 can be further divided to indicate more precisely the nature of the soil material. Within each group, the relative engineering value of the soil material may be indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest. Index numbers are shown in parentheses following the group symbol; for example, A–6(9).

TABLE 3.—*Estimated engineering*

Soil type and map symbol	Depth from surface	Classification		
		USDA	Unified	AASHO
	Inches			
Bethany silt loam (BeA)	0 to 18	Silt loam	ML, CL	A–4
	18 to 50	Clay	CL, CH	A–7
	50 to 64	Silty clay loam	CL	A–6, A–7
Breaks-Alluvial land complex (Bk) [2]	0 to 10	Clay	CL, CH	A–7
	10	Shale.		
Broken alluvial land (Br)	0 to 12	Fine sandy loam	ML, CL	A–4
	12 to 48	Loamy fine sand	SM	A–2
Carwile loam (Ca)	0 to 15	Loam	ML	A–4
	15 to 50	Clay	CL	A–6, A–7
Drummond soils (Dr)	0 to 7	Loam	ML, CL	A–4
	7 to 22	Clay loam	CL	A–6
	22 to 50	Fine sandy loam	SM, SC	A–2
Eroded clayey land (Ec)	0 to 6	Clay	CH	A–7
	6	Shale		
Grant silt loam (GaA, GaB, GaC, GaC2, GnD, GnD2, GnE, GnE2). (For Nash part of mapping units GnD, GnD2, GnE, and GnE2, refer to Nash silt loam in this table.)	0 to 87	Silt loam	ML, CL	A–4, A–6
Kingfisher silt loam (KfB, KfC2, KlD2) (For properties of Lucien part of mapping unit KlD2, refer to Lucien very fine sandy loam in this table.)	0 to 10	Silt loam	ML–CL	A–4
	10 to 48	Silty clay loam	CL–ML	A–6 A–7
	48	Slightly weathered shale		
Kirkland silt loam (KnA, KrB, KsA) (For properties of Renfrow part of mapping unit KrB, refer to Renfrow silt loam in this table. About 25 percent of KsA is moderately saline slickspots.)	0 to 12	Silt loam	ML–CL	A–4
	12 to 60	Clay	CL, CH	A–7
Lucien very fine sandy loam (LuC)	0 to 14	Very fine sandy loam	ML	A–4
	14	Sandstone		
Meno loamy fine sand (MeB)	0 to 34	Loamy fine sand	SM	A–2
	34 to 56	Sandy clay loam	SC, CL	A–4
Miller clay (Mr, Ms) (10 to 30 percent of Ms is moderately saline slickspots.)	0 to 60	Clay	MH, CH	A–7
Nash silt loam (NaB, NaC)	0 to 22	Silt loam	ML–CL	A–4
	22	Sandstone or siltstone		
Norge loam (NoB, NoC, NoC2, NoD, NoD2)	0 to 20	Loam	ML, CL	A–4
	20 to 56	Clay loam	CL	A–6
Pond Creek silt loam (PcA, PcB)	0 to 12	Silt loam	ML	A–4
	12 to 68	Silty clay loam	ML, CL	A–6, A–7
Port clay loam (Po)	0 to 48	Clay loam	CL	A–6
Port silt loam (PrA, PrB)	0 to 48	Silt loam	ML, CL	A–4
Pratt loamy fine sand (PsB, PtC)	0 to 14	Loamy fine sand	SM	A–2
	14 to 56	Loamy sand	SM	A–2
Pulaski fine sandy loam (Pu)	0 to 30	Fine sandy loam	SM	A–2, A–4
	30 to 48	Fine sand	SM	A–2
Reinach loam (Rc, Re) (25 percent of Re is moderately saline slickspots.)	0 to 8	Loam	ML, CL	A–4
	8 to 50	Very fine sandy loam	ML	A–4
Renfrow clay loam (RfA, RfB)	0 to 11	Clay loam	CL	A–6, A–7
	11 to 48	Clay	CL, CH	A–7

properties of soils

Percentage passing sieve — No. 4 (4.7 mm.)	Percentage passing sieve — No. 10 (2.0 mm.)	Percentage passing sieve — No. 200 (0.074 mm.)	Available water capacity	Reaction	Shrink-swell potential	Permeability [1]	Hydrologic [1] soil group
			Inches per inch of soil	*pH value*			
100	100	75 to 90	0.14	6.5 to 7.3	Low to moderate	Slow	C.
100	100	90 to 100	.17	7.4 to 8.4	High.		
100	100	85 to 95	.17	7.9 to 8.4	Moderate.		
100	100	90 to 100	.17	6.5 to 8.4	High	Very slow	D.
100	100	60 to 80	.14	6.5 to 7.3	Low	Moderately rapid	B.
100	100	11 to 30	.07	7.4 to 8.0	Low		
100	100	55 to 85	.14	6.1 to 6.5	Low	Very slow	C.
100	100	85 to 100	.17	6.6 to 8.4	Moderate.		
100	100	55 to 85	.14	7.4 to 7.8	Low	Very slow	C.
100	100	75 to 95	.17	7.9 to 8.4	Moderate.		
100	100	20 to 35	.12	8.5	Low.		
100	100	90 to 100	.17	6.6 to 8.4	High	Very slow	D.
				7.4 to 8.4			
100	100	75 to 95	.14	6.6 to 8.4	Low to moderate	Moderate	B.
100	100	75 to 90	.14	6.1 to 7.3	Low to moderate	Moderately slow	C.
100	100	85 to 90	.17	6.1 to 7.8	Moderate.		
				7.4 to 8.4			
100	100	75 to 90	.14	6.1 to 6.5	Low to moderate	Very slow	D.
100	100	90 to 100	.17	6.6 to 8.4	High.		
100	100	60 to 80	.14	6.1 to 6.5	Low	Moderate	D.
				6.6 to 7.3			
100	100	15 to 35	.07	5.6 to 6.0	Low	Moderately rapid	B.
100	100	40 to 60	.12	5.6 to 6.0	Low		
100	100	90 to 100	.17	7.4 to 8.4	High	Very slow	D.
100	100	75 to 90	.14	6.1 to 7.3	Low	Moderate	C.
				6.6 to 8.4			
100	100	55 to 85	.14	6.1 to 7.3	Low	Moderately slow	C.
100	100	75 to 95	.17	6.6 to 7.8	Moderate.		
100	100	75 to 95	.14	6.1 to 7.3	Low	Moderately slow	C.
100	100	85 to 95	.17	6.6 to 8.4	Moderate.		
100	100	75 to 95	.17	6.5 to 8.4	Moderate	Moderately slow	B.
100	100	75 to 90	.14	6.5 to 8.4	Low to moderate	Moderate	B.
100	100	11 to 30	.07	6.1 to 7.3	Low	Rapid	A.
90 to 100	90 to 100	15 to 35	.07	7.4 to 8.4	Low.		
100	100	20 to 40	.12	6.1 to 7.3	Low	Moderately rapid	B.
100	100	11 to 20	.05	6.6 to 7.3	Low.		
100	100	55 to 85	.14	6.6 to 7.3	Low	Moderate	B.
100	100	60 to 80	.14	7.4 to 8.4	Low.		
100	100	85 to 90	.17	6.1 to 7.3	Moderate	Very slow	D.
100	100	90 to 100	.17	7.4 to 8.4	High.		

TABLE 3.—*Estimated engineering*

Soil type and map symbol	Depth from surface	Classification		
		USDA	Unified	AASHO
	Inches			
Renfrow silt loam (RsC, RvC2) (For properties of Vernon part of mapping unit RvC2, refer to Vernon clay loam.)	0 to 12 12 to 42	Silt loam Clay	ML–CL CL, CH	A–4 A–7
Shellabarger fine sandy loam (ShA, ShB)	0 to 10 10 to 60	Fine sandy loam Sandy clay loam	SM SC, CL	A–2 A–4
Shellabarger-Carwile fine sandy loams (SrB) (Estimates are for Carwile part of mapping unit; refer to Shellabarger fine sandy loam for Shellabarger part.)	0 to 12 12 to 56	Fine sandy loam Clay	SM CL	A–2 A–7
Tabler silt loam (TaA)	0 to 12 12 to 56	Silt loam Clay	ML CH	A–4 A–7
Vernon clay loam (VcC2, Vs)	0 to 18 18	Clay loam Shale or claybeds.	CL, CH	A–6, A–7
Vernon soils (VrD)	0 to 10 10	Clay Shale.	CL, CH	A–7
Vernon soils and Rock outcrop (Vs)	0 to 6 6	Clay Shale or sandstone.	CL, CH	A–7
Weymouth-Ost loams (WoB)	0 to 10 10 to 58	Loam Clay loam	ML, CL CL	A–4 A–6
Zaneis loam (ZaB, ZaC, ZaC2)	0 to 10 10 to 47	Loam Clay loam	ML CL	A–4 A–6

[1] The rating for permeability and the letter designating the hydrologic group apply to the whole profile.

In the Unified classification (7), the soils are grouped on the basis of their texture and plasticity and their performance as material for engineering structures. Soil materials are identified as gravels (G), sands (S), silts (M), clays (C), organic (O), or highly organic (Pt). Clean sands are identified by the symbol SW and SP; sands mixed with fines of silt and clay are identified by the symbols SM and SC; silts and clays that have a low liquid limit are identified by the symbols ML and CL; and silts and clays that have a high liquid limit are identified by the symbols MH and CH.

The U.S. Department of Agriculture classifies soils according to texture, which is determined by the proportion of sand, silt, and clay in the soil material. The terms "sand," "silt," and "clay" are defined in the Glossary at the back of this survey.

Estimated engineering properties of soils

Table 3 provides estimates on some of those physical properties of soils that affect engineering. The estimates are for a profile typical of each soil type. The thickness of each horizon is shown in the column headed "Depth."

Where test data are available, the estimates are based on test data for the modal, or typical, profile. If tests were not performed for a soil, the estimates are based on test data obtained for similar soils in this county, or on test data obtained from soils of other counties. Past experiences in engineering are considered in the estimates. Since the estimates are only for the modal soils, considerable variation from these estimates should be anticipated. Following are explanations of some of the columns in table 3.

Available water capacity, also "available moisture capacity," is the amount of moisture in a soil that is available to plants. Available water capacity is expressed in inches of moisture per inch of soil depth. When soil material is air dry, this amount of moisture will wet it to a depth of 1 inch, but not penetrate deeper.

Reaction is expressed in terms of pH values. A pH of 4.5 to 5.0 indicates very strong acidity, and a pH of 9.1 or higher indicates very strong alkalinity.

Shrink-swell potential refers to the change in volume of a soil that results from a change in moisture content. The estimates are based on tests of volume change or on observation of physical properties and characteristics of the soils. The soil material from the B horizon of Kirkland silt loam, for example, is very sticky when wet and crusts extensively when it dries; hence, this material has high shrink-swell potential. In contrast, the material from the A horizon of Pratt loamy fine sand is structureless and nonplastic, and for this reason, has low shrink-swell potential.

Permeability relates only to movement of water downward through undisturbed soil. The estimates on permeability are for the soil as it occurs in place, and are based on soil structure and porosity. Plowpans, surface crusts, and such mechanically created restrictions on permeability are not considered in estimating permeability.

properties of soils—Continued

Percentage passing sieve			Available water capacity	Reaction	Shrink-swell potential	Permeability [1]	Hydrologic soil group [1]
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)					
			Inches per inch of soil	*pH value*			
100	100	75 to 90	0.14	6.1 to 7.3	Low	Very slow	D.
100	100	90 to 100	.17	7.4 to 8.4	High.		
100	100	20 to 35	.12	5.6 to 6.0	Low	Moderate	B.
100	100	40 to 60	.12	5.6 to 7.3	Low.		
100	100	20 to 35	.12	6.1 to 6.5	Low	Very slow	D.
100	100	90 to 100	.17	6.6 to 7.8	Moderate.		
100	100	80 to 100	.14	5.6 to 7.3	Low	Very slow	D.
100	100	90 to 100	.17	6.6 to 8.4	High.		
100	100	75 to 95	.17	7.4 to 8.4	Moderate	Very slow	D.
100	100	90 to 100	.17	7.4 to 8.4	Moderate to high	Very slow	D.
100	100	90 to 100	.17	7.4 to 8.4	High	Very slow	D.
100	100	55 to 85	.14	7.4 to 8.4	Low	Moderately slow	C.
100	100	75 to 95	.17	7.9 to 8.4	Moderate.		
100	100	55 to 85	.14	6.1 to 6.5	Low	Moderately slow	C.
100	100	75 to 95	.17	6.1 to 7.3	Moderate.		

[2] No rating given for Alluvial land component.

The verbal ratings for permeability, and the numerical equivalents, are as follows: Very slow, less than 0.05 inch; slow, 0.05 to 0.20; moderately slow, 0.20 to 0.80; moderate, 0.80 to 2.50; moderately rapid, 2.50 to 5.00; rapid, 5.00 to 10.00; very rapid, over 10.00.

A hydrologic soil group is a group of soils having similar rates of infiltration, when wetted, and similar rates of water transmission within the soil. Four such groups currently are recognized.

Soils in group A have a high infiltration rate, even when thoroughly wetted. They have a high rate of water transmission and low runoff potential. The soils of this group are deep, are well-drained to excessively drained, and consist chiefly of sand, gravel, or both.

Soils in group B have a moderate infiltration rate when thoroughly wetted. Their rate of water transmission and runoff potential are both moderate. These soils are moderately deep to deep, are moderately well drained to well drained, and are of fine to moderately coarse texture.

Soils of group C have a slow infiltration rate when thoroughly wetted. Their rate of water transmission is slow, and their potential runoff is high. These soils have a layer that impedes downward movement of water, or they are of moderately fine to fine texture and have a slow infiltration rate.

Soils of group D have a very slow infiltration rate when thoroughly wetted. Their rate of water transmission is very slow, and runoff potential is very high. In this group are (1) clay soils with high shrink-swell potential; (2) soils with a permanent high water table; (3) soils with claypan or clay layer at or near the surface; and (4) soils shallow over nearly impervious material.

Some soils listed in table 3 are subject to flooding, have a high water table, or are affected by numerous slickspots. These limitations affect the following mapping units:

Frequent flooding:
- Broken alluvial land (Br).

Occasional flooding:
- Port clay loam (Po).
- Port silt loam, 0 to 1 percent slopes (PrA).
- Port silt loam, 1 to 3 percent slopes (PrB).
- Pulaski fine sandy loam (Pu).
- Reinach-Slickspots complex (Re).

Numerous slickspots:
- Kirkland-Slickspots complex (KsA).
- Reinach-Slickspots complex (Re).

Seasonally high water table:
- Carwile loam (Co).
- Drummond soils (Dr).
- Miller clay (Mr).
- Miller-Slickspots complex (Ms).
- Shellabarger-Carwile fine sandy loams, undulating (SrB).

Engineering interpretations of soils

In table 4 the soils of Garfield County are rated according to their suitability as a source of topsoil, select grading material, and road fill; and then those features affecting their suitability as sites for highways, farm ponds, drainage systems, terraces, and waterways are pointed out. The information in table 4 is based on the estimated

TABLE 4.—*Engineering*

Soil series, land types, and map symbols	Suitability as source of— Topsoil	Select grading material	Road fill
Bethany (BeA)	Good to depth of 1½ feet.	Unsuitable	Poor: moderate to high shrink-swell potential.
Breaks-Alluvial land complex (Bk)	Poor: mixed soil material; limited quantity.	Poor: inaccessible; too clayey.	Poor: limited quantity of material.
Broken alluvial land (Br)	Fair: mixed soil material; limited quantity; inaccessible.	Poor: limited access	Good
Carwile (Ca)	Poor to fair: limited material.	Poor	Poor: seasonal high water table.
Drummond (Dr)	Poor: saline	Poor: easily dispersed	Poor: saline
Eroded clayey land (Ec)	Poor: shallow clayey material.	Unsuitable: highly plastic.	Poor: high shrink-swell potential; parent material close to surface; in the slick-spots material is dispersed by salts.
Grant silt loam (GaA, GaB, GaC, GaC2)	Good to fair	Unsuitable	Poor: requires close moisture control; unstable when wet.
Grant-Nash silt loams (GnD, GnD2, GnE, GnE2)	Good to fair	Unsuitable	Poor: requires close moisture control; unstable when wet.
Kingfisher (KfB, KfC2)	Good to fair	Unsuitable	Poor: unstable when wet.
Kingfisher-Lucien complex (KlD2)	Poor to fair: limited depth of suitable material.	Unsuitable	Poor: unstable when wet.
Kirkland (KnA, KrB) (For interpretation of Renfrow part of mapping unit KrB, refer to Renfrow in this table.)	Poor	Unsuitable	Poor to very poor: highly plastic.
Kirkland-Slickspots complex (KsA)	Poor: saline soil	Unsuitable	Poor to very poor: highly plastic; contains saline areas.
Lucien (LuC)	Poor: easily eroded and quantity limited.	Poor: suitable material but quantity limited.	Limited quantity of borrow material; sandstone at depth of 1 foot.
Meno (MeB)	Poor: too sandy; low fertility.	Good in entire profile	Good when slopes are stabilized.

interpretations of soils

Soil features affecting engineering practices					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Unstable, clayey subsoil.	Features favorable for dug ponds; few natural impoundment sites.	Features favorable	Well drained	Long slopes; nearly level topography.	Nearly level topography.
Broken topography; narrow deep valleys and side slopes.	Good natural depth; possible abutment seepage.	Rocky soil material	Excessive surface drainage.	Nonarable	Steep slopes; narrow valleys.
Broken topography; frequently flooded.	Flooding and high seepage potential;	Flooding; possible seepage.	Flooding	Nonarable	Broken slopes; flooded.
Seasonal high water table; highly plastic.	Features favorable for dug ponds.	Features favorable for homogenous fills.	Imperfectly drained; depressional topography.	Nearly level to slightly depressional topography.	Nearly level to slightly depressional topography.
Seasonal high water table; poorly drained.	Features favorable for dug ponds.	Unstable soil material.	Imperfectly drained; high water table; saline.	Nonarable	Vegetation difficult to establish.
Some steep slopes; highly plastic.	Limited depth to shale.	Limited borrow material.	Nonarable	Nonarable	Vegetation hard to establish; slickspots common; little topsoil.
Well drained; nearly level to gently rolling topography.	Features favorable	Features favorable	Well drained	Features favorable	Features favorable.
Strongly to steeply sloping.	Limited depth to sandstone at some locations; some lateral seepage.	Limited borrow material at some locations.	Excessive surface runoff.	Strongly to steeply sloping; gullied areas.	Strongly to steeply sloping; gullied areas.
Unstable foundation materials.	Features favorable	Features favorable	Well drained	Features favorable	Features favorable.
Strongly sloping	Features favorable	Features favorable	Excessive surface runoff.	Strongly sloping; eroded.	Strongly sloping; eroded.
Highly plastic subsoil; poor internal drainage.	Features favorable	Cracks when dry	Moderately well drained surface; internal drainage very slow.	Features favorable	Features favorable.
Nearly level; highly plastic; poor internal drainage.	Features favorable	Highly plastic; easily dispersed.	Moderately well drained surface; internal drainage very slow.	Slickspots unstable	Slickspots unstable and droughty.
Internal seepage on slopes; sandstone close to surface.	Sandstone close to surface; high seepage.	Limited borrow material; variable seepage.	Well drained	Features favorable except for shallow areas.	Easily eroded; droughty.
Features favorable	Undulating topography; probably high seepage.	Highly erosive; high seepage.	Moderately well drained.	Susceptible to wind erosion; undulating topography.	Susceptible to wind erosion; undulating topography.

TABLE 4.—*Engineering*

Soil series, land types, and map symbols	Suitability as source of—		
	Topsoil	Select grading material	Road fill
Miller (Mr, Ms) (10 to 30 percent of Ms is moderately saline slickspots.)	Poor: clayey	Poor: highly plastic	Poor: highly plastic
Nash (NaB, NaC)	Good to fair	Fair to poor: unsuitable when wet; elastic.	Good: rock at depth of 2 feet.
Norge (NoB, NoC, NoC2, NoD, NoD2)	Good	Fair to poor: quite elastic.	Fair to poor: requires close moisture control; unstable when wet.
Pond Creek (PcA, PcB)	Good	Unsuitable	Poor: requires close moisture control; unstable when wet.
Port (Po, PrA, PrB)	Good	Unsuitable	Poor: unstable when wet.
Pratt (PsB, PtC)	Poor: low fertility; erosive.	Good	Good when slopes are stabilized.
Pulaski (Pu)	Poor: too erosive	Good	Good: slopes may need stabilizing.
Reinach (Re, Re) (Up to 25 percent of Re consists of slickspots.)	Poor: erosive and numerous slickspots.	Fair: numerous slickspot areas.	Good to poor: slickspots are unstable.
Renfrow (RsC, RfA, RfB)	Poor: shallow suitable soil over clay.	Unsuitable: too clayey	Poor: highly plastic.
Renfrow-Vernon complex (RvC2)	Poor: too shallow and clayey.	Unsuitable: too clayey	Poor: high shrink-swell potential; shallow depth to shale or claybeds.
Shellabarger (ShA, ShB)	Good except for surface foot.	Good	Good
Shellabarger-Carwile (SrB)	Poor: too sandy	Shellabarger part good: Carwile part poor.	Shellabarger part good; Carwile part poor.
Tabler (TaA)	Poor: shallow depth to clay.	Unsuitable	Highly plastic clay below depth of 1 foot.
Vernon (VcC2)	Poor: too clayey and shallow.	Unsuitable: highly plastic; shallow	Poor: shale or sandstone close to surface.

interpretations of soils—Continued

Soil features affecting engineering practices					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
High water table; occasionally flooded; highly plastic; nearly level.	Features favorable for dug ponds; flooded.	Low stability; subject to severe cracking.	Imperfectly drained; local seasonal high water table; flooded.	Level topography; flooded.	Subject to flooding; level topography.
Sandstone at depth of about 2 feet.	Limited depth to sandstone.	Limited borrow material.	Well drained	Sandstone close to surface at some locations.	Sandstone close to surface at some locations.
Unstable clayey subsoil.	Features favorable	Features favorable	Well drained	Features favorable; some areas severely eroded.	Features favorable; some steeply sloping and eroded areas.
Unstable clayey subsoil.	Features favorable for dug ponds.	Features favorable	Well drained	Features favorable	Features favorable.
Unstable clayey soils; occasionally flooded.	Features favorable for dug ponds.	Features favorable	Well drained	Occasionally flooded; nearly level topography.	Occasionally flooded; nearly level topography.
Cuts easily eroded	High seepage	Erosive soil; high seepage.	Internal drainage excessive.	Undulating and hummocky topography; subject to wind erosion.	Droughty; subject to wind erosion.
Occasionally flooded	High seepage; flooded.	High seepage	Internal drainage somewhat excessive.	Level topography	Level topography.
Occasionally flooded; slickpots are unstable.	Features favorable for dug ponds.	Features favorable; slickspots unstable.	Well drained	Nearly level topography.	Nearly level topography.
Highly plastic subsoil material.	Features favorable	Highly plastic material.	Surface runoff excessive	Features favorable	Features favorable.
Shale or claybeds between depth of 1 and 3 feet.	Shale or claybeds at depth of about 1 to 3 feet.	Limited material; highly plastic.	Surface runoff excessive.	Some shallow soil; severely eroded.	Droughty soil; badly gullied.
Features favorable	Seepage potential at depth below about 5 feet.	Features favorable	Well drained	Features favorable; subject to some wind erosion.	Features favorable; subject to some wind erosion.
Poorly drained in depressional areas.	Features favorable in Carwile part; Shellabarger part has high seepage potential.	High seepage potential in Shellabarger part.	Poorly drained depressional areas have no outlets.	Moundy and depressional areas.	Moundy and depressional areas.
Highly plastic subsoil; poorly drained.	Features favorable for dug ponds.	Unstable material; highly plastic.	Moderately well drained; internal drainage slow.	Nearly level topography.	Nearly level topography.
Moderately to steeply sloping; sandstone or shale near surface.	Shallow soils; steep slopes.	Limited borrow material.	Surface runoff excessive.	Shallow soil; eroded.	Shallow soil; eroded and droughty.

TABLE 4.—*Engineering*

Soil series, land types, and map symbols	Suitability as source of—		
	Topsoil	Select grading material	Road fill
Vernon soils (VrD)	Poor: too clayey and shallow	Unsuitable: highly plastic; shallow.	Poor: shale or sandstone close to surface
Vernon soils and Rock outcrop (Vs)	Poor: too clayey and shallow.	Unsuitable: highly plastic; shallow.	Poor: shale or sandstone close to surface
Weymouth-Ost (WoB)	Good	Poor: too clayey	Good
Zaneis (ZaB, ZaC, ZaC2)	Good	Fair: somewhat clayey	Good

engineering properties in table 3, the actual test data in table 5, and field experience with the soils.

Topsoil is presumed fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens. The suitability of a soil as a source of topsoil depends largely upon texture and depth. It is necessary that topsoil be of a texture that works to a good seedbed, yet contains enough clay to resist erosion on strong slopes. The depth of suitable material determines whether or not it is economical to use the soil as a source of topsoil.

Select grading material has suitable grain size and favorable content of silt and clay. Soils that are primarily sand are good grading material if binder is added to increase cohesion. Clay soils, in contrast, compress under load and rebound when unloaded, and for this reason are poor grading material.

Road fill can be of almost any soil material. Sandy clays and sandy clay loams offer few problems in placement or compaction. Clays with a high shrink-swell potential, however, require special compaction and close moisture control both during and after construction. Sands compact well but are difficult to confine in a fill. The ratings in table 4 reflect the various limitations and advantages of the different kinds of soil materials.

Although the detailed soil map and table 4 serve as a guide for evaluating most soils, a detailed investigation at the site of the proposed construction is needed because as much as 15 percent of an area designated as a specific soil on the map may consist of areas of other soils too small to be shown on the published map. By comparing the soil description with the result of investigations at the site, the presence of an included soil can usually be determined.

Engineering test data

Table 5 contains test data on soil samples collected during the survey of Garfield County. The samples were tested by the Oklahoma State Highway Department. Only selected soils were chosen for sampling and testing. The results of the tests are reported in table 5 in customary engineering terms, some of which may require explanation.

Shrinkage of a soil is decrease in volume, in proportion to loss in moisture. As moisture is removed, shrinkage continues to a limit, beyond which no further decrease in volume occurs, though additional moisture is removed. The moisture content at which shrinkage stops is called the shrinkage limit. This limit is a general index of clay content and, ordinarily, is a low number for soils that contain a great deal of clay. The shrinkage limit of a sand that contains little or no clay, however, is close to the liquid limit and is considered insignificant. As a rule, the load carrying capacity of a soil is maximum when its moisture content is at or below the shrinkage limit. Sands do not follow this rule, because sands, if confined, have uniform load carrying capacity throughout a considerable range of moisture content.

The shrinkage ratio expresses the relation between the volume change of a soil and the corresponding change in water content, above the shrinkage limit. The volume change used in computing shrinkage ratio is the change that takes place in a soil when it dries from a given moisture content to the shrinkage limit.

Field moisture equivalent (FME) is the minimum moisture content at which a smooth soil surface will absorb no more water in 30 seconds when the water is added in individual drops. It is the moisture content required to fill all the pores in sands and to approach saturation in cohesive soils in their natural state. Volume change from field moisture equivalent is the change in volume, expressed as a percentage of the dry volume, that takes place when the moisture content of the soil mass is reduced from the field moisture equivalent to the shrinkage limit.

Mechanical analyses involves sorting soil components by particle size. All soils can be divided as either coarse grained or fine grained, according to percentage of particles passing the No. 200 sieve. Sand and other granular materials are retained on the No. 200 sieve, but silt and clay materials pass through it. Clay is that fraction passing the No. 200 sieve that is smaller than 0.002 millimeter

interpretations of soils—Continued

Soil features affecting engineering practices					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Moderately to steeply sloping; sandstone or shale near surface.	Shallow soils; steep slopes.	Limited borrow material.	Surface runoff excessive.	Shallow soil; eroded.	Shallow soil; eroded and droughty.
Moderately to steeply sloping; sandstone or shale near surface.	Shallow soils; steep slopes.	Limited borrow material.	Surface runoff excessive.	Shallow soil; eroded.	Shallow soil; eroded and droughty.
Features favorable	Features favorable for dug ponds.	Features favorable	Well drained	Nearly level (Weymouth) and undulating (Ost).	Nearly level (Weymouth) and undulating (Ost).
Features favorable	Features favorable	Features favorable	Well drained	Features favorable	Features favorable.

in diameter. Material 0.074 to 0.005 millimeter in diameter is called silt.

Liquid limit and plastic limit indicate the effect of water on the consistence of soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Some silty and sandy soils are nonplastic; that is, they do not become plastic at any moisture content.

Classification and Morphology of Soils

This section contains a discussion of the major factors of soil formation; a classification of the soils according to the current system; and technical descriptions of each soil series in the county.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent materials, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are active factors of soil formation. They act on parent material that has accumulated through the weathering of rocks and slowly change it into a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. Parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. The time may be much or little, but some time is always required for differentiation of horizons. Generally a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four.

Parent materials

In parent material the dominance of any one particle size (sand, silt, or clay) affects the other factors of soil formation, and thus the development of the soil profile. Soils developed from sandstone, for example, generally have moderately coarse textured B horizons, but those developed from shales have fine-textured B horizons.

The physical and chemical properties of the parent materials affect the processes of soil formation. The more complex the mineral composition of the parent rock, the more easily it weathers. Various minerals within the parent rock expand and contract, to varying degree, with changes in temperature. Thus, mineral content of the rock affects exfoliation of the rock and formation of parent material. In Garfield County most of the parent materials do not weather rapidly because they were derived from sandstone and shale, which are not of complex mineralogical composition.

The parent materials of soils in Garfield County belong to three main geologic systems, the Permian, Quaternary, and Recent. About two-thirds of the county is underlain by rocks of Permian age. The two main formations are the Hennessey shale and Garber sandstone. The major soil series in this part of the county are the Kirkland, Renfrow, and Vernon.

TABLE 5.—*Engineering*

Soil name and location	Parent material	Oklahoma report number	Depth	Horizon	Shrinkage		Volume change from field moisture equivalent
					Limit	Ratio	
			Inches		*Percent*		*Percent*
Carwile loam: 1,800 feet W. of NE. corner, sec. 16, T. 20 N., R. 8 W.	Eolian sands.	SO-6199	0 to 8	Ap	[5] NP	[5] NP	[5] NP
		SO-6200	15 to 22	B1	18	1. 76	7
		SO-6201	22 to 46	B2	10	2. 03	61
Grant silt loam: 660 feet W. of S¼ corner, sec. 24, T. 21 N., R. 7 W.	Sandstone.	SO-6193	0 to 6	A1	24	1. 60	8
		SO-6194	16 to 30	B2	19	1. 75	22
		SO-6195	43 to 55	C1	17	1. 78	27
Lucien very fine sandy loam: 1,320 feet N. of SE. corner, sec. 9, T. 20 N., R. 3 W.	Sandstone.	SO-6211	0 to 6	A1	20	1. 65	8
		SO-6212	14 to 18	C	NP	NP	NP
Miller clay: 1,320 feet W. of NE. corner, sec. 16, T. 21 N., R. 8 W.	Alluvium.	SO-6196	0 to 5	Ap	12	1. 95	52
		SO-6197	12 to 32	AC	11	2. 03	77
		SO-6198	32 to 40	C	9	2. 10	78
Pond Creek silt loam: 300 feet S. of NE. corner, SE¼, sec. 11, T. 23 N., R. 8 W.	High alluvial terrace.	SO-6202	0 to 6	Ap	19	1. 72	8
		SO-6203	22 to 30	B2	13	1. 94	53
		SO-6204	30 to 46	B3	11	1. 99	59
Tabler silt loam: 700 feet W. of SE. corner, SE¼, sec. 29, T. 23 N., R. 4 W.	Eolian mantle.	SO-6205	0 to 8	Ap	20	1. 71	5
		SO-6206	12 to 30	B2	11	1. 98	61
		SO-6207	30 to 48	B3	10	2. 03	68
Zaneis loam: 400 feet W. of NE. corner, SW¼, sec. 23, T. 21 N., R. 3 W.	Sandstone and shale.	SO-6208	0 to 10	A1	17	1. 74	9
		SO-6209	18 to 25	B2	13	1. 91	44
		SO-6210	40 to 56	C	16	1. 78	13

[1] Tests performed by the Oklahoma Department of Highways in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

[2] Mechanical analyses according to the AASHO Designation T 88(*1*). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

The Quarternary, or loess, deposits in the county are loamy and sandy materials that are less than 40 feet thick in most places. They occur largely in the southwestern part of the county. The dominant soil series in this area are the Pratt, Shellabarger, and Carwile.

Climate

Elements of climate, including precipitation, temperature, humidity, and wind, greatly affect soil formation by supplying the energy that hastens the decomposition and distintegration of parent material. Either directly or indirectly they cause many variations in plant and animal life.

Moisture is one of the primary elements of climate. Through the processes of solution and hydration, moisture works on mineral and organic matter to form a soil.

Temperature is next in importance. During long winter seasons when temperatures are low and little heat is accumulated, soil conditions are unfavorable for percolation. In regions of high temperature, the loss of evaporation reduces the amount of moisture available for percolation, which contributes to the formation of lime zones in some soils. In hot, arid regions, high evaporation impedes the effects of leaching; and it causes salts to move upward, where they modify other factors of soil formation.

Winds act indirectly in forming soil by influencing the rate of evaporation. They also act directly by carrying fine particles of soil material, and in this way can prevent or curtail the development of the A horizon.

Plant and animal life

Earthworms, micro-organisms, and other biological forms of life within the soil create energy and certain forms of chemicals that react on the soil mass.

Plants act both directly and indirectly in soil formation. Their roots penetrate rock and mineral material, serve as channels for drainage, and in some instances are the passages where minerals carried by ground waters are deposited. Roots excrete a number of acid substances that act on rocks and minerals and bring certain of their constituents into solution. When the plants die, they decompose into humus and minerals, which give rise to organic and inorganic acids. Decomposition also releases

test data [1]

Mechanical analysis [2]						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—			Percentage smaller than—						
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.			AASHO [3]	Unified [4]
100	99	59	38	10	8	[5] NP	[5] NP	A-4(5)	ML.
100	99	69	48	16	13	22	2	A-4(7)	ML.
100	99	85	77	44	39	47	24	A-7-6(15)	CL.
----------	100	97	88	17	14	30	4	A-4(8)	ML.
----------	100	99	93	28	25	33	11	A-6(8)	ML-CL.
----------	100	99	91	28	25	34	12	A-6(9)	ML-CL.
----------	100	63	37	12	10	23	1	A-4(6)	ML.
----------	100	45	22	12	10	NP	NP	A-4(2)	SM.
----------	100	99	96	49	41	44	19	A-7-6(12)	ML-CL.
100	99	98	95	60	51	69	41	A-7-6(20)	CH.
----------	100	98	94	64	56	65	35	A-7-5(20)	MH-CH.
----------	100	95	85	19	16	24	3	A-4(8)	ML.
----------	100	94	85	43	37	45	20	A-7-6(13)	ML-CL.
----------	100	94	88	46	39	47	21	A-7-6(14)	ML-CL.
100	99	97	88	20	17	25	3	A-4(8)	ML.
----------	100	98	91	52	47	53	28	A-7-6(18)	CH.
----------	100	97	92	49	43	56	31	A-7-6(19)	CH.
----------	100	70	54	18	14	23	2	A-4(7)	ML.
----------	100	79	70	36	32	40	17	A-6(11)	CL.
----------	100	47	37	24	22	27	8	A-4(2)	SC.

[3] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (pt. 1, ed. 8): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation M 145-49. The Oklahoma Department of Highways classification procedure further subdivides the AASHO A-2-4 subgroup into the following: A-2-3(0) when the plasticity index equals nonplastic; A-2(0) when the plasticity index equals nonplastic (NP) to 5; and A-2-4(0) when the plasticity index is 5 to 10.

[4] Based on the Unified Soil Classification System, Technical Memorandum No. 3-357, v. 1, Waterways Experiment Station, Corps of Engineers, March, 1953 (7). The SCS and BPR have agreed to consider that all soils having plasticity indexes within 2 points from the A-line are to be given a borderline classification. An example of a borderline classification thus obtained is ML-CL.

[5] NP=Nonplastic.

some minerals that remain in the profile, and others that are leached out.

Plants indirectly participate in soil formation through their effects on climate. In addition to making the climate milder, forests cut down on the sweep of winds, and to a certain extent, regulate the rate of evaporation during the summer. The temperature of the soil and air is lowered by forest and other plant cover. Another way that plant cover affects soil formation is through its protective action against the forces of weathering. The soils of Garfield County were formed under a grass cover, and the effect of this vegetation is apparent in the soils.

Relief and drainage

Relief conditions or redistributes matter and energy, and in this manner affects soil formation. The soils of this county range from nearly level to steep, and for this reason, all of the following effects of relief are evident in the county.

On steep slopes, much water runs off and erosion removes the products of weathering. For this reason, parent material generally is near the surface on steep slopes. Also, a comparatively small part of the rainfall enters the profile, and consequently the B horizon of soils on steep slopes is either lacking or poorly defined.

The soils that have a deep profile are those in nearly level areas or on gentle slopes where there is little runoff. In some of these soils, leaching of minerals and colloids has taken place to such extent that a claypan has formed in the subsoil.

In poorly drained areas where the water table is high, decay of organic materials is slow or incomplete. At times, also, moisture moves from the water table to the surface by capillary action, and carries with it dissolved salts that are deposited at or near the surface when evaporation takes place.

Gradient and direction of slope affect temperature, air and moisture supply in the soil, and these, in turn, affect the type and amount of vegetation. Vegetation lessens runoff and increases soil development. Direction of slope affects radiation and absorption of heat. Slopes facing south receive more heat, which encourages decomposition of rock and formation of parent material. Thus, if gradients and soil materials are similar, soils on south-facing

slopes tend to be deeper than those on slopes facing in other directions.

Time

Time is necessary for the weathering of parent material and the formation of soil. The time required for the development of a soil depends upon a number of factors, some of which can be mentioned here.

The degree of profile development depends upon the nature of the soil materials, the intensities of the various soil-forming factors, and how long these factors have been active. If the factors of soil formation have not operated long enough to form a soil that contains definite horizons, the soil is considered young. Vernon clay loam and Lucien very fine sandy loam, for example, are young soils. If the soils have been in place for a long time and have approached equilibrium with their environment, they tend to have well-developed horizons and are considered mature. The Bethany, Kirkland, Norge, Grant, and Pond Creek are mature soils.

Classification of Soils

Soils are placed in narrow classes for the organization and application of knowledge about their behavior within farms, ranches, or counties. They are placed in broad classes for study and comparison of large areas, such as continents.

Two systems of classifying soils are in general use in the United States. One is the 1938 system (*2*, *4*), with later revisions. The other system (*3*, *6*) was placed in general use in the Soil Conservation Service in 1965. In table 6 the soil series of Garfield County are classified according to the current system, and the great soil group for each series under the old system is provided.

Under the current system, all soils are placed in six categories. They are, beginning with the most inclusive, the order, suborder, great group, subgroup, family, and series. In this system the criteria used as bases for classification are observable or measurable properties. The properties are so chosen, however, that soils of similar mode of origin are grouped together.

The 1938 system, with later revisions, also has six categories. In the highest of these, the soils of the whole country have been placed in three orders. Two categories, suborder and family, were never fully developed. As a consequence, they have not been used much. More attention has been centered on the categories of great soil group, soil series, and soil type. A further subdivision of the soil type, called a soil phase, is defined, along with soil type and soil series, in the section "How This Soil Survey Was Made", in the front of this survey.

Bethany Series

In the Bethany series are well-drained soils that occur in association with soils of the Kirkland and Tabler series.

Profile of a Bethany silt loam in a cultivated field (1,200 feet north of the southwest corner of sec. 22, T. 23 N., R. 5 W.):

A1—0 to 11 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; friable; slightly acid, pH 6.5; clear boundary.

B1—11 to 18 inches, dark-brown (10YR 4/3) light silty clay loam, dark brown (10YR 3/3) when moist; moderate, fine, granular structure; firm when moist; permeable; neutral, pH 7.0; clear boundary.

TABLE 6.—*Soil series classified according to the current system and the revised 1938 system of classification*

Series	Current classification			1938 classification
	Family	Subgroup	Order	Great soil group
Bethany	Fine, mixed, thermic	Udic Paleustolls	Mollisols	Reddish Prairie.
Carwile	Fine, mixed, thermic	Aquic Argiustolls	Mollisols	Planosol.
Drummond	Fine, mixed, thermic	Typic Natrustalfs	Alfisols	Solonetz.
Grant	Fine silty, mixed, thermic	Udic Argiustolls	Mollisols	Reddish Prairie.
Kingfisher	Fine silty, mixed, thermic	Udic Argiustolls	Mollisols	Reddish Prairie.
Kirkland	Fine, mixed, thermic	Vertic Paleustolls	Mollisols	Reddish Prairie.
Lucien	Loamy, mixed, thermic	Lithic Udic Haplustolls	Mollisols	Lithosol.
Meno	Fine loamy, mixed, thermic	Aquic Arenic Haplustalfs	Alfisols	Prairie.
Miller	Fine, mixed, thermic	Udertic Haplustolls	Mollisols	Alluvial.
Nash	Coarse silty, mixed, thermic	Udic Haplustolls	Mollisols	Regosol.
Norge	Fine silty, mixed, thermic	Udic Paleustolls	Mollisols	Reddish Prairie.
Ost	Fine loamy, mixed, thermic	Typic Argiustolls	Mollisols	Chernozem.
Pond Creek	Fine silty, mixed, thermic	Udic Argiustolls	Mollisols	Reddish Prairie.
Port	Fine loamy, mixed, thermic, moist	Fluventic Haplustolls	Mollisols	Alluvial.
Pratt	Sandy, siliceous, thermic	Udic Haplustalfs	Alfisols	Chestnut.
Pulaski	Coarse loamy, siliceous nonacid, thermic, moist.	Typic Ustifluvents	Entisols	Alluvial.
Reinach	Coarse silty, mixed, thermic	Udic Haplustolls	Mollisols	Alluvial.
Renfrow	Fine, mixed, thermic	Vertic Paleustolls	Mollisols	Reddish Prairie.
Shellabarger	Fine loamy, mixed, thermic	Udic Argiustolls	Mollisols	Reddish Prairie.
Tabler	Fine, mixed, thermic	Vertic Paleustolls	Mollisols	Chernozem intergrading to Planosol.
Vernon	Fine, mixed, thermic, shallow	Typic Ustochrepts	Inceptisols	Lithosol.
Weymouth	Fine loamy, mixed, thermic	Haplic Calciustolls	Mollisols	Calcisol.
Zaneis	Fine loamy, mixed, thermic	Udic Argiustolls	Mollisols	Reddish Prairie.

B2t—18 to 30 inches, dark-brown (10YR 4/3) light clay, dark brown (10YR 3/3) when moist; moderate, medium, blocky structure; very firm when moist, very hard when dry; neutral, pH 7.0; gradual boundary.

B3—30 to 42 inches, dark grayish-brown (10YR 4/2) light clay, very dark grayish brown (10YR 3/2) when moist; moderate, coarse, blocky structure; very hard and compact when dry; moderately alkaline, pH 8.0; contains many small concretions of calcium carbonate; gradual boundary.

C1—42 to 50 inches, brown (10YR 5/3) light clay, dark brown (10YR 4/3) when moist; weak, coarse, blocky structure to massive; very hard and compact when dry; weakly calcareous; a few large concretions of calcium carbonate; gradual boundary.

C2—50 to 64 inches, dark-brown (7.5YR 4/4, moist) silty clay loam; massive, friable; calcareous; distinct streaks of gray (5YR 6/1, moist) and prominent specks of yellowish red (5YR 4/6, moist).

The A horizon ranges from very dark grayish brown (10YR 3/2) to dark brown (7.5YR 3/2). The depth to the compact clayey B2t horizon ranges from 14 to 22 inches and averages about 18 inches.

Carwile Series

Soils of the Carwile series are somewhat poorly drained and developed in eolian deposits. They have a mottled clayey subsoil and are in nearly level areas or slight depressions. Associated soils are the Pratt and Shellabarger. The Carwile soils have a finer textured B horizon and lack the desirable drainage of either the Pratt or the Shellabarger.

Profile of a Carwile loam in a nearly level cultivated field (1,000 feet west of the northeast corner of sec. 9, T. 20 N., R. 8 W.):

A1—0 to 10 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; slightly acid, pH 6.5; clear boundary.

B1—10 to 15 inches, very dark grayish-brown (10YR 3/2) heavy loam, very dark brown (10YR 2/2) when moist; friable when moist, hard when dry; slightly acid, pH 6.5; abrupt boundary.

B2t—15 to 30 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; moderate, medium, blocky structure; very firm when moist, extremely hard when dry; neutral, pH 7.0; distinct gray and brown mottling; gradual boundary.

B3ca—30 to 38 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; weak, medium, blocky structure; very firm when moist, extremely hard when dry; calcareous; many calcium carbonate concretions; distinct gray and brown mottling; gradual boundary.

C—38 to 50 inches +, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; massive; very firm when moist, extremely hard when dry; calcareous.

In this county Carwile fine sandy loam is mapped only in a complex with Shellabarger fine sandy loam. As mapped, this Carwile soil includes some areas where the surface layer is loamy fine sand. Mottles in the B22t horizon and C horizon range from few to many, from faint to prominent, and from gray to yellowish brown. Concretions of calcium carbonate in the C horizon range from few to common. The C horizon generally contains fewer concretions than the B3ca horizon.

Drummond Series

The Drummond series consists of soils that developed from loamy earths of various colors and geological origins, but for the most part they formed in stratified old alluvium. They have a solodized, columnar or massive B horizon of clay loam to light clay. The water table fluctuates 2 to 10 feet below the surface. These soils occur along small streams and on some of the higher stream terraces.

Profile in a native meadow (185 feet south and 35 feet east of the northwest corner of sec. 8, T. 21 N., R. 8 W.):

A1—0 to 7 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; generally has a vesicular crust up to one-half-inch thick, and grades to porous and massive below; friable when moist, hard when dry; noncalcareous; abrupt, wavy boundary.

B2t—7 to 16 inches, brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; weak columnar structure, and the column faces coated with dark-brown shiny films; friable when moist, very hard and compact when dry; noncalcareous; a few fine concretions of calcium carbonate; clear boundary.

B3—16 to 22 inches, reddish-brown (5YR 4/4) clay loam, dark reddish brown (5YR 3/4) when moist; weakly mottled with various shades of brown; massive; friable when moist, very hard when dry; calcareous; a few fine concretions of calcium carbonate; gradual boundary.

C—22 to 50 inches, reddish-brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) when moist; contains strata that are more sandy or clayey; massive; friable when moist, hard when dry; calcareous.

The A horizon ranges from 3 to 15 inches in thickness. Its color is in the 10YR hue, with dry values of 3 to 6 and moist values of 2 to 4, and with chromas of 2 to 3, either dry or moist. The texture of the surface layer ranges from fine sandy loam to clay loam. The B horizon ranges from clay loam to light clay and from columnar structure to massive. The substratum is of varied color and contains strata having sandy loam to clay texture. White crystals are common in these soils at a depth of about 15 inches.

Grant Series

Grant soils are deep, granular, and neutral. They have a reddish-brown subsoil, and they developed from reddish, calcareous, silty or loamy earths rich in phosphorus and potash. These soils are on nearly level to moderately steep uplands, where they are associated with Pond Creek and Nash soils. Grant soils are more strongly sloping than the Pond Creek soils and have a slightly coarser texture in their B horizon. Grant soils are deeper than Nash soils and are calcareous at a greater depth from the surface.

Profile of a Grant silt loam on a slope of 2 percent, at the southwest edge of Waukomis (660 feet west of the south quarter corner of sec. 24, T. 21 N., R. 7 W.):

A11—0 to 6 inches, reddish-brown (5YR 4/4) silt loam, dark reddish brown (5YR 3/4) when moist; weak, medium, granular structure; friable when moist, soft when dry; noncalcareous; abrupt, smooth boundary.

A12—6 to 16 inches, reddish-brown (5YR 4/4) silt loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, granular structure; friable when moist, soft when dry; worm casts moderately numerous; no clay films seen; noncalcareous; gradual boundary.

B21t—16 to 30 inches, reddish-brown (5YR 4/4) heavy silt loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; porous; worm casts numerous; a few weak clay skins coat vertical faces of peds; noncalcareous; gradual boundary.

B22t—30 to 43 inches, yellowish-red (5YR 4/6) light silty clay loam, yellowish red (5YR 3/6) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; noncalcareous; gradual boundary.

C1—43 to 55 inches, red (2.5 YR 5/6) silt loam, red (2.5 YR 4/6) when moist; few roundish white spots; massive; friable when moist, hard when dry; noncalcareous; clear boundary.

C2—55 to 87 inches +, similar to above horizons except that this horizon is calcareous and slightly harder in the upper 12 inches.

Silt loam is the dominant type, but some small areas of very fine sandy loam occur. The B21t horizon ranges from heavy silt loam to light silty clay loam. The depth of the A horizon ranges from 12 to 18 inches.

Kingfisher Series

Soils in the Kingfisher series are associated with Grant soil. They developed over slightly more clayey red beds than the Grant soil and therefore have a finer textured B horizon.

Profile of Kingfisher silt loam, on a slope of 2 percent, facing west, in a cultivated field (1,600 feet north of the southwest corner of sec. 27, T. 21 N., R. 8 W.):

A1—0 to 10 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; slightly acid, pH 6.5; clear boundary.

B1—10 to 15 inches, dark-brown (7.5YR 4/2) light silty clay loam, dark brown (7.5YR 3/2) when moist; moderate fine to medium, granular structure; friable when moist, hard when dry; slightly acid, pH 6.5; clear boundary.

B2t—15 to 29 inches, reddish-brown (2.5YR 4/4) heavy silty clay loam, dark reddish brown (2.5YR 3/4) when moist; moderate, medium, subangular blocky structure; firm when moist, extremely hard when dry; neutral to mildly alkaline, pH 7.0 to 7.5; gradual boundary.

B3—29 to 48 inches, red (2.5YR 4/6) silty clay loam, dark red (2.5YR 3/6) when moist; moderate, coarse, blocky structure; firm when moist, hard when dry; mildly alkaline, pH 7.5; a few concretions of iron and calcium carbonate.

R—48 inches +, red, calcareous, slightly weathered shale.

The A horizon ranges from 7 to 12 inches in thickness. In some small areas its texture is loam or very fine sandy loam. The color of the B horizon ranges from red (2.5YR 5/6) and dark red (2.5YR 3/6) to reddish brown (5YR 4/3).

Kirkland Series

In the Kirkland series are soils that developed in alkaline reddish clays and shales, commonly of the Permian red beds. Kirkland soils are associated with the Renfrow and Tabler soils. They are not so gray at the surface as the Tabler. Their B horizon is brown or dark brown, in contrast to the red or reddish-brown B horizon in the Renfrow soils.

Profile of Kirkland silt loam in a nearly level cultivated field (75 feet south of the northwest corner of the southwest quarter of sec. 26, T. 21 N., R. 5 W.):

A1—0 to 12 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; slightly acid, pH 6.5; abrupt boundary.

B21t—12 to 25 inches, dark-brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist; very firm when moist; weak, medium to coarse, blocky structure; very hard when dry; neutral, pH 7.0; gradual boundary.

B22t—25 to 32 inches, dark-brown (7.5YR 4/4) clay, dark brown (7.5YR 3/4) when moist; weak, coarse, blocky structure to massive; very firm when moist, extremely hard when dry; moderately alkaline, pH 8.0; a few, fine, distinct red (2.5YR 5/8) specks; gradual boundary.

B3—32 to 44 inches, dark-brown (10YR 4/3) clay, dark brown (10YR 3/3) when moist; massive; very firm when moist, extremely hard when dry; moderately alkaline, pH 8.0; many fine and some large calcium carbonate concretions, a few, small, black iron concretions, and a few, distinct, coarse and fine red (2.5YR 5/8) specks; clear boundary.

C—44 to 60 inches +, yellowish-red (5YR 5/6) clay, yellowish red (5YR 4/6) when moist; massive; firm when moist, hard when dry; moderately alkaline, pH 8.0.

The A horizon ranges from 10YR to 7.5YR in hue. It is 8 to 14 inches thick. In some places there is a 2-inch horizon of silty clay loam or clay loam just above the B2 horizon. The depth to the C horizon ranges from 42 to 48 inches.

Lucien Series

The Lucien are noncalcareous soils that formed under grass. They are associated with the Vernon soils, but they developed in material derived from sandstone and are therefore more permeable than the Vernon soils, which developed in shaly material.

Profile of Lucien very fine sandy loam in native pasture, on a slope of 4 percent and facing northeast (1,320 feet north of the southeast corner of sec. 9, T. 20 N., R. 3 W.):

A1—0 to 6 inches, reddish-brown (5YR 4/4) very fine sandy loam, reddish brown (5YR 4/3) when moist; weak, fine, granular structure; friable when moist, soft when dry; slightly acid, pH 6.5; clear boundary.

AC—6 to 14 inches, red (2.5YR 4/6) very fine sandy loam, dark red (2.5YR 3/6) when moist; weak, fine, granular structure to single grained; friable when moist, loose when dry; slightly acid, pH 6.5; abrupt boundary.

R—14 to 18 inches +, red (2.5YR 5/6) slightly weathered sandstone, red (2.5YR 4/6) when moist; sandstone noncalcareous and contains many hard fragments of unweathered sandstone.

The profile ranges from neutral to medium acid. The color of the surface layer ranges from dark reddish brown to reddish brown. The depth to the R horizon ranges from 10 to 20 inches.

Meno Series

Meno soils occur in association with the Pratt, Shellabarger, and Carwile soils. They are lighter colored and coarser textured in the A horizon and not so dark or fine textured in the B horizon as the Carwile soils. They are finer textured in the B horizon than the Pratt soils. They are more mottled at lower depths than the Shellabarger and are generally finer textured.

Profile of Meno loamy fine sand in a slighty undulating cultivated field (1,200 feet south and 800 feet east of the northwest corner of sec. 31, T 21 N., R. 8 W.):

A1—0 to 18 inches, grayish-brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, loose when dry; medium acid, pH 6.0; gradual boundary.

A3—18 to 34 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 3/3) when moist; single grain; loose

when moist, and loose when dry; medium acid, pH 6.0; clear boundary.

B21t—34 to 44 inches, light brownish-gray (10YR 6/2) sandy clay loam, grayish brown (10YR 5/2) when moist; moderate, medium, subangular blocky structure; firm when moist, hard when dry; medium acid, pH 6.0; a few, distinct, yellowish-brown specks; iron concretions numerous; gradual boundary.

B22t—44 to 56 inches +, light brownish-gray (10YR 6/2) heavy sandy clay loam, grayish brown (10YR 5/2) when moist; massive; medium acid, pH 6.0; a few yellowish-brown specks and a few iron concretions.

The A horizon ranges from 14 to 34 inches in thickness. The depth to the B22t horizon ranges from 34 to 46 inches. Mottles range from few to many, from faint to prominent, and from browns to yellowish browns.

Miller Series

The Miller soils are reddish-brown, calcareous, clayey soils having a compact subsoil. They occur along large and small streams in all parts of the county. They are redder and more poorly drained than the Port or the Reinach soils, and are also more calcareous and finer textured in the subsoil.

Profile of a Miller clay in a wheatfield (1,320 feet west and 100 feet south of the northeast corner of sec. 16, T. 21 N., R. 8 W.):

A—0 to 6 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) when moist; strong, medium, granular structure; friable when moist, slightly hard when dry; calcareous; clear boundary.

AC—6 to 23 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) when moist; weak blocky structure to massive; very firm when moist, very hard when dry; calcareous; gradual boundary.

C—23 to 48 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) when moist; massive; very plastic when wet, extremely hard when dry; calcareous.

The A horizon ranges from 5 to 10 inches in thickness and from dark reddish brown (2.5YR) to reddish brown (5YR) in hue. The A horizon is noncalcareous in places. The depth to the C horizon ranges from 20 to 30 inches, and the color from dark red (2.5YR 3/6) to dark reddish brown (5YR 3/3) when moist.

Nash Series

In the Nash series are reddish brown, neutral or calcareous, moderately deep soils that developed from silty shale or standstone. They are associated with Grant and Pond Creek soils, but they are not so deep as either, and are not so fine textured in the B horizon as the Pond Creek.

Typical profile of a Nash silt loam (400 feet south and 500 feet east of the northwest corner of sec. 23, T. 24 N., R. 7 W.):

A1—0 to 10 inches, reddish-brown (5YR 4/4) silt loam, dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; slightly acid to neutral, pH 6.5 to 7.0; gradual boundary.

B2—10 to 22 inches, yellowish-red (5YR 4/6) silt loam, yellowish red (5YR 3/6) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; worm casts numerous; mildly alkaline, pH 7.5; gradual boundary.

R—22 inches +, reddish-yellow (5YR 6/8) weekly consolidated sandstone, yellowish red (5YR 4/8) when moist; calcareous.

The thickness of the A1 horizon ranges from 8 to 10 inches. Depth to the R horizon ranges from 20 to 36 inches. In some places horizontal bedding of gray siltstone occurs in the R horizon. The lower part of the B2 horizon in places calcareous.

Norge Series

The Norge series consists of soils that developed in calcareous or alkaline old alluvium. These soils are adjacent to flood plains along the larger streams in the county. They are in association with Renfrow soils, but they are not nearly so fine textured in the B horizon as the Renfrow.

Profile of a Norge loam in a cultivated field (at the southwest corner of the southeast quarter of sec. 12, T. 22 N., R. 3 W.):

A1—0 to 10 inches, brown (7.5YR 5/3) loam, dark brown (7.5YR 3/3) when moist; weak, fine, granular structure; friable when moist, soft when dry; slightly acid, pH 6.5; gradual boundary.

B1—10 to 20 inches, reddish-brown (5YR 5/4) light clay loam, reddish brown (5YR 4/4) when moist; moderate, medium, granular structure; friable when moist, slighty hard when dry; slightly acid to neutral, pH 6.5 to 7.0; a few small, clear quartz grains; gradual boundary.

B2t—20 to 28 inches, reddish-brown (5YR 4/4) heavy clay loam, dark reddish brown (5YR 3/3) when moist; moderate, medium, subangular blocky structure; firm when moist, slightly hard when dry; neutral, pH 7.0; gradual boundary.

B3—28 to 42 inches, reddish-brown (5YR 5/3) heavy clay loam, reddish brown (5YR 4/3) when moist; moderate, medium, subangular blocky structure; firm when moist, hard when dry; neutral, pH 7.0; clear boundary.

C—42 to 56 inches +, yellowish-red (5YR 5/6) clay loam, yellowish red (5YR 4/6) when moist; massive: friable when moist, slightly plastic when wet; mildly alkaline, pH 7.5.

In some small areas the surface layer is very fine sandy loam and ranges from brown to reddish brown in hue. The subsoil ranges from reddish brown (2.5YR 4/4) to yellowish red (5YR 4/6) in hue. Some profiles of Norge soils, especially those on gentle and strong slopes, contain quartz grains and some small and large waterworn gravel in all layers below the surface layer.

Ost Series

Soils of the Ost series are mapped only in a complex with the Weymouth soils in this county. The Ost soils are not so red at lower depths as are the Weymouth soils. Their B21t horizon is about 6 inches thick, and they are noncalcareous to a depth of about 18 inches.

Profile of an Ost loam, undulating, in a wheatfield (1,200 feet west of the southeast corner of the northeast quarter of sec. 17, T. 23 N., R. 6 W.):

A1—0 to 12 inches, dark-brown (7.5YR 4/2) loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; neutral, pH 7.0; clear boundary.

B21t—12 to 18 inches, dark-brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, subangular blocky structure; friable when moist, hard when dry; mildly alkaline, pH 7.5; clear boundary.

B22t—18 to 24 inches, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 4/4) when moist; moderate, medium, subangular blocky structure; friable when moist, hard when dry; moderately alkaline, pH 8.0: clear boundary.

B3ca—24 to 36 inches, reddish-yellow (7.5YR 6/6) clay loam, strong brown (7.5YR 5/6) when moist; about half of the soil of this horizon is a brown (7.5YR 5/5) clay loam, dark brown (7.5YR 4/4) when moist; weak, medium, subangular blocky structure; friable when moist, hard when dry; many concretions of iron and calcium carbonate; calcareous; gradual boundary.

Cca2—36 to 54 inches +, reddish-yellow (5YR 6/8) light clay loam, yellowish red (5YR 5/8) when moist; massive; calcareous; calcium carbonate and iron concretions many.

The A horizon ranges from 8 to 12 inches in thickness, and the B21t horizon from 4 to 7 inches. The texture of the B22t horizon ranges from mostly clay loam to light clay or silty clay loam. Color is dark brown to brown and yellowish brown. Depth to the calcareous soil ranges from 12 to 26 inches.

Pond Creek Series

The Pond Creek soils are dark-brown, very fertile, well-drained soils that have a permeable subsoil. They are immature upland soils that formed in calcareous loesslike earth. They are in association with Grant and Nash soils, but are slightly less permeable and are on more level landscape than either. They are much deeper than the Nash soils.

Profile of Pond Creek silt loam on level topography (300 feet south of the northeast corner of the southeast quarter of sec. 11, T. 23 N., R. 8 W.):

Ap—0 to 6 inches, dark-brown (7.5YR 4/4) silt loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; slightly acid, pH 6.5; gradual boundary.

A12—6 to 12 inches, dark-brown (7.5YR 4/4) silt loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; neutral, pH 7.0; gradual boundary.

B1—12 to 22 inches, reddish-brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) when moist; strong, coarse, granular structure to weak, fine, subangular blocky structure; neutral, pH 7.0; gradual boundary.

B2t—22 to 30 inches, reddish-brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) when moist; moderate, fine, subangular blocky structure; firm when moist, hard when dry; neutral, pH 7.0; patchy clay films; gradual boundary.

B3—30 to 46 inches, reddish-brown (5YR 4/3) heavy silty clay loam or light clay, dark reddish brown (5YR 3/3) when moist; strong, medium, subangular blocky structure; firm when moist, hard when dry; neutral, pH 7.0; gradual boundary.

C—46 to 68 inches, reddish-brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) when moist; massive; calcareous; few small concretions of calcium carbonate.

The A horizon ranges from 12 to 16 inches in thickness and from dark brown to very dark grayish brown in hue. The depth to calcareous material ranges from 4 to 6 feet. The color of the C horizon ranges from reddish brown to yellowish red.

Port Series

The Port soils are deep and have an alkaline to calcareous subsoil. They formed on wide stream terraces and in large stream valleys that are rarely to occasionally flooded. They are associated with the Reinach, Pulaski, and Miller soils. The Port soils have a finer textured subsoil and are darker than the Reinach. They have a darker, finer textured, thicker surface layer than the Pulaski soils and are less subject to flooding. Also, the Port soils are not so clayey as the Miller and are ordinarily darker.

Profile of Port silt loam (2,100 feet east of the southwest corner of sec. 23, T. 22 N., R. 6 W.):

A—0 to 10 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; slightly acid, pH 6.5; gradual boundary.

AC—10 to 20 inches, dark-brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; neutral to mildly alkaline, pH 7.0 to 7.8; gradual boundary.

C—20 to 48 inches +, reddish-brown (5YR 4/4) heavy silt loam, dark reddish brown (5YR 3/4) when moist; moderate, coarse, granular structure; friable when moist, hard when dry, moderately alkaline, pH 8.0.

The A horizon ranges from 8 to 14 inches in thickness and from dark brown to dark reddish brown in hue. In some places the texture of the surface layer is a light silt loam, and in other small areas the surface layer is a silty clay loam. The color of the subsoil ranges from dark reddish brown (5YR 3/2) to reddish brown (5YR 5/4). The depth to the C horizon ranges from 20 to 34 inches.

Pratt Series

Pratt soils are relatively young, sandy, nuetral, grassland soils that developed in comparatively recent eolian deposits. Their subsoil is somewhat coherent and contains little clay or no more clay than the surface horizon. Pratt soils occur in association with Carwile and Shellabarger soils. The subsoil of the Pratt is not so fine textured and compact as the subsoil of the Carwile, nor is it so fine textured as the subsoil of the Shellabarger.

Profile of a Pratt loamy fine sand, undulating, in a maize field (650 feet north of the southwest corner of the northwest quarter of sec. 7, T. 20 N., R. 8 W.):

A1—0 to 14 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 3/3) when moist; weak, fine, granular structure to single grain; friable when moist; loose when dry; slightly acid, pH 6.5; gradual boundary.

B2—14 to 24 inches, brown (7.5YR 5/4) loamy sand, dark brown (7.5YR 4/4) when moist; weak, fine, granular structure to single grain; friable when moist, loose when dry; slightly acid, pH 6.5; gradual boundary.

C—24 to 56 inches +, reddish-yellow (7.5YR 6/6) loamy sand; light brown (7.5YR 6/4) when moist; weak, medium, granular structure; friable when moist, loose when dry; neutral, pH 7.0; clear boundary.

Loamy fine sand is the only type of soil in the Pratt series mapped in this county, but there are a few small areas with a fine sandy loam surface layer. The color of the A horizon ranges from dark yellowish brown (10YR 4/4) to brown (10YR 5/3) or dark brown (7.5YR 3/2). The texture of the B2 horizon ranges from loamy fine sand to light sandy loam.

Pulaski Series

The Pulaski series consists of moderately coarse textured, neutral to mildly alkaline soils derived from recent sediments. They occur in association with the Port and Reinach soils, but they are coarser textured, lighter colored, stronger in structure, and at a somewhat lower elevation than these.

Profile of a Pulaski fine sandy loam in a cultivated field (700 feet east and 1,200 feet north of the southwest corner of sec. 5, T. 22 N., R. 7 W.):

A—0 to 14 inches, reddish-brown (5YR 4/3) fine sandy loam, dark reddish brown (5YR 3/3) when moist; weak, fine, granular structure; friable when moist, soft when dry; slightly acid, pH 6.5; gradual boundary.

AC—14 to 30 inches, reddish-brown (5YR 4/4) fine sandy loam, dark reddish brown (5YR 3/4) when moist, weak, fine, granular structure; friable when moist; neutral, pH 7.0; gradual boundary.

C—30 to 48 inches, yellowish-red (5YR 5/8) fine sand, yellowish red (5YR 4/8) when moist; single grain; loose when dry; neutral, pH 7.0.

The A horizon ranges from 8 to 18 inches in thickness. The AC horizon is loamy sand at depths of 12 to 26 inches in some places. The C horizon contains seams of coarse sand in some places. Depth to fine or coarse sand ranges from 30 to 48 inches.

Reinach Series

In the Reinach series are reddish-brown, youthful soils developed in calcareous alluvium. They are closely related to the Port and Pulaski soils, but lie a few feet higher than the Pulaski, above ordinary overflow. At lower depths the Reinach are not so stratified nor so sandy as those of the Pulaski. The Reinach soils are on about the same topographic level as the Port, but are not so dark as the Port.

Profile of a Reinach loam in a cultivated field (100 feet east of the southwest corner of the northwestern quarter of sec. 27, T. 22 N., R. 8 W.):

A—0 to 8 inches, reddish-brown (5YR 4/3) loam, dark reddish brown (5YR 3/3) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; neutral, pH 7.0; gradual boundary.

AC—8 to 22 inches, reddish-brown (5YR 4/4) heavy very fine sandy loam, dark reddish brown (5YR 3/4) when moist; weak, coarse, granular structure; friable when moist, slightly hard when dry; neutral, pH 7.0; gradual boundary.

C—22 to 50 inches +, yellowish-red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) when moist; single grain; friable when moist, loose when dry; porous; calcareous; a few streaks of reddish yellow (5YR 6/6, moist) coarser material.

The depth of the A horizon ranges from 7 to 15 inches. The color of the AC horizon ranges from yellowish red (5YR 5/8) to reddish brown (5YR 4/3), and the texture from very fine sandy loam to light silt loam.

Renfrow Series

Renfrow soils developed in weakly calcareous red beds on residual uplands. They are associated with the Kirkland and Vernon soils, but have a red or reddish-brown profile in contrast to the brown or dark brown one of the Kirkland soils. The Renfrow are deeper than the Vernon, but are of about the same color. The Renfrow have a B horizon; the Vernon do not.

Profile of a gently sloping Renfrow silt loam in a native meadow (1,400 feet south and 100 feet east of the northwest corner of sec. 12, T. 23 N., R. 3 W.):

A1—0 to 7 inches, reddish-brown (5YR 4/3) silt loam, dark reddish brown (5YR 3/3) when moist; moderate, fine, granular structure; friable when moist, slightly hard when dry; slightly acid, pH 6.5; clear boundary.

A3—7 to 12 inches, dusky-red (2.5YR 3/2) silt loam; dark reddish brown (2.5YR 3/4) when moist; moderate, medium, granular structure; firm when moist, hard when dry; neutral, pH 7.0; clear boundary.

B2t—12 to 30 inches, reddish-brown (2.5YR 4/4) clay; dark reddish brown (2.5YR 3/4) when moist; moderate, coarse, blocky structure; very firm when moist, very hard when dry; mildly alkaline, pH 7.5; many, small, round iron concretions; calcareous; gradual boundary.

B3—30 to 42 inches, dark-red (2.5YR 3/6, moist) clay; massive; very firm when moist, very hard when dry; calcareous; many, small, black iron concretions; clear boundary.

R—42 to 58 inches +, dark-red (2.5YR 3/6) intermixed clay ranging to slightly weathered, calcareous, soft, gray shale.

The A horizon ranges from 8 to 12 inches in thickness and from weak red (2.5YR 4/2) to dark reddish brown (5YR 3/3). The lower B horizon ranges from mildly alkaline to strongly calcareous in reaction and from dark reddish brown (2.5YR 2/4) to red (2.5YR 4/6).

Shellabarger Series

The Shellabarger soils are well-drained, moderately coarse textured soils that formed in loamy eolian deposits. They occur in association with the Carwile and Pratt soils. Shellabarger soils are slightly finer textured in the B horizon than the Pratt, but not nearly so fine textured as the Carwile.

Profile of a Shellabarger fine sandy loam (1,300 feet east and 150 north of the southwest corner of sec. 26, T. 20 N., R. 8 W.):

A1—0 to 10 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; medium acid, pH 6.0; clear boundary.

B21t—10 to 26 inches, brown (7.5YR 5/4) sandy clay loam, dark brown (7.5YR 4/4) when moist; moderate, medium, subangular blocky structure; friable when moist, hard when dry; medium acid, pH 6.0; gradual boundary.

B22t—26 to 38 inches, strong-brown (7.5YR 5/6) light sandy clay loam, dark brown (7.5YR 4/4) when moist; weak, fine subangular blocky structure; friable when moist, slightly hard when dry; slightly acid, pH 6.5; gradual boundary.

C—38 to 60 inches, reddish-yellow (7.5YR 6/6) loam, strong brown (7.5YR 5/6) when moist; structureless; loose when dry; neutral, pH 7.0.

The A horizon ranges from 8 to 12 inches in thickness and from dark brown to dark grayish brown in hue. The depth to the B22t horizon ranges from 26 to 36 inches. In many places the C horizon is a sandy loam.

Tabler Series

The Tabler soils developed in calcareous clays derived from red beds or other shales, or from an eolian mantle. They are in association with Kirkland and Bethany soils. The Tabler soils are less well drained than the Bethany. Tabler soils are grayer than the Bethany, and their A horizon is not so thick.

Profile of Tabler silt loam in a field of barley (700 feet west of the southeast corner of sec. 29, T. 23 N., R. 4 W.):

A11—0 to 8 inches, gray (10YR 5/1) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, loose when dry; medium acid, pH 6.0; clear boundary.

A12—8 to 12 inches, gray (10YR 6/1) heavy silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; friable when moist,

slightly hard when dry; neutral, pH 7.0; abrupt boundary.

B2t—12 to 30 inches, gray (10YR 5/1) clay, very dark gray (10YR 3/1) when moist; strong, coarse, blocky structure; firm when moist, hard when dry; neutral, pH 7.0; gradual boundary.

B3—30 to 48 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; massive; very plastic when wet, extremely hard when dry; calcareous; a few small calcium carbonate concretions; gradual boundary.

Cca—48 to 56 inches +, same as horizon above, but many more calcium carbonate concretions, and more calcareous.

The surface layer ranges from gray to very dark grayish brown, and the B2t layer from gray to dark grayish brown. The depth to the A12 horizon ranges from 8 to 14 inches, and this horizon is 2 to 4 inches thick. Gray mottles, variable in number and distinctness, may occur below a depth of 24 inches in the B2t and the B3 horizons.

Vernon Series

In the Vernon series are reddish-brown, calcareous soils developed from the clays and shales of the Permian red beds. They are in association with the Lucien, Renfrow, and Zaneis soils. The Vernon is not so deep as the Renfrow or Zaneis, nor so heavy as the Lucien. It is about the same color as the Renfrow. The Vernon is calcareous, and the Zaneis and Lucien are neutral to medium acid soils that developed in material derived from sandstone.

Profile description of a Vernon clay loam in a cultivated field (2,100 feet south of the northwest corner of sec. 15, T. 22 N., R. 6 W.):

Ap—0 to 5 inches, reddish-brown (2.5YR 4/4) clay loam, dark reddish brown (2.5YR 3/4) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; calcareous; gradual boundary.

AC—5 to 18 inches, reddish-brown (2.5YR 4/4) light clay, dark reddish brown (2.5YR 3/4) when moist; weak blocky structure; friable when moist, hard when dry; calcareous; abrupt boundary.

R—18 inches +, reddish-brown (2.5YR 4/4) shale, dark reddish brown (2.5YR 3/4) when moist; when crushed, red (2.5YR 4/6); calcareous; a few calcium carbonate concretions.

The color of the A horizon ranges from reddish brown (2.5YR) to dark reddish brown (5YR). The Ap horizon in some places is only moderately alkaline. The Ap and AC horizons range from 5 to 20 inches in thickness. In some areas the R horizon is intermixed with gray shale; and in other areas it is in red claybeds.

Weymouth Series

Soils of the Weymouth series are well-drained and formed in strongly calcareous old alluvium.

Profile of a Weymouth loam in wheat stubble (200 feet west of the southeast corner of the northeast quarter of sec. 17, T. 23 N., R. 6 W.):

A1—0 to 10 inches, dark-brown (10YR 4/3) loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; calcareous; many fine calcium carbonate concretions; gradual boundary.

B1—10 to 16 inches, dark-brown (7.5YR 4/2) light clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; friable when moist, hard when dry; calcareous; many fine and a few large calcium carbonate concretions; clear boundary.

B2—16 to 24 inches, reddish-brown (5YR 5/4) light clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, granular structure; firm when moist, hard when dry; calcareous; many fine calcium carbonate concretions; clear boundary.

B3—24 to 32 inches, reddish-yellow (5YR 6/6) clay loam, yellowish red (5YR 4/6) when moist; moderate, medium, subangular blocky structure; firm when moist, hard when dry; calcareous; many fine calcium carbonate concretions; gradual boundary.

C1ca—32 to 40 inches, yellowish-red (5YR 5/8) clay loam, yellowish red (5YR 4/8) when moist; massive; firm when moist, hard when dry; calcareous; many fine and some large calcium carbonate concretions, and a few small iron concretions; gradual boundary.

C2ca—40 to 58 inches +, same as horizon above, but many more fine iron concretions.

The surface soil ranges from dark brown (7.5YR) to grayish brown (10YR) in hue. The depth of the A horizon ranges from 8 to 12 inches. The depth to the C horizon ranges from 28 to 34 inches.

Zaneis Series

The Zaneis soils are slightly acidic to neutral soils of the uplands that developed in weakly consolidated Permian red beds, which contained alternating bands of sandstone and shale.

Profile of a Zaneis loam on a 2 percent slope facing east, in a field once cultivated but now in annual and some perennial grasses (200 feet east of the southwest corner of the southeast quarter of sec. 23, T. 21 N., R. 3 W.):

A1—0 to 10 inches, reddish-brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; slightly acid, pH 6.5; clear boundary.

B1—10 to 18 inches, reddish-brown (5YR 4/3) clay loam, dark reddish brown (5YR 3/3) when moist; strong, coarse, granular structure; friable when moist, hard when dry; slightly acid, pH 6.5; gradual boundary.

B2t—18 to 24 inches, yellowish-red (5YR 5/6) clay loam, yellowish red (5YR 4/6) when moist; moderate, medium, subangular blocky structure; firm when moist, hard when dry; neutral, pH 7.0; gradual boundary.

B3—24 to 36 inches, yellowish-red (5YR 5/8) light clay loam, yellowish red (5YR 4/8) when moist; moderate, medium to coarse, subangular blocky structure; firm when moist, hard when dry; a very few lime concretions; neutral, pH 7.0; clear boundary.

C—36 to 47 inches, red (2.5YR 5/6) light clay loam, red (2.5YR 4/6) when moist; massive; friable when moist, slightly hard when dry; neutral, pH 7.0; abrupt boundary.

R—47 inches +, red (2.5YR 4/6) noncalcareous, slightly weathered sandstone.

The A horizon ranges from 8 to 12 inches in thickness. The principal texture in this horizon is loam, but in some areas it is very fine sandy loam. The B horizon ranges from red to reddish brown or yellowish red in hue. The A and B horizons range from medium acid to neutral. The R horizon consists of soft sandstone beginning at a depth of about 47 inches; the depth ranges from 36 to 48 inches.

General Facts About the County

Garfield County was once a part of Indian territory called the Cherokee Strip. The Federal Government bought this land from the Cherokee Nation in 1893, and on September 16 of that year, the territory was opened for settlement. The settlers came mostly from Kansas, Texas, Missouri, and the Western States. Garfield

County was established in 1907, and named for President Garfield.

The county remains largely agricultural. The crops are those that withstand shortage of moisture. Winter wheat is the leading crop. Other crops are oats, barley, grain sorghum, and sudangrass. Among the legume crops are alfalfa, sweetclover, Austrian Winter peas, vetch, cowpeas, and mung beans.

Enid, the county seat and principal city, has a population of approximately 45,000. Smaller towns in the county are Garber, Covington, Hayward, Douglas, Bison, Waukomis, Drummond, Lahoma, Carrier, Hillsdale, Kremlin, and Hunter.

Most industry in the county is related to agriculture. Grain elevators, flour and feed mills, creameries, milk condenseries, and bakeries are located in the county. Oil refineries, machine shops, drilling equipment manufacturers, and headquarters for oil companies contribute to the economy.

The county is served by U.S. Highway Nos. 60, 64, and 81. State and county blacktop roads connect the towns, and fair to good dirt or all-weather roads border almost every section of land. Lines of the Chicago, Rock Island and Pacific Railroad, the St. Louis-San Francisco Railway, and the Atchison, Topeka and Santa Fe Railway serve the county.

Physiography of the County

Garfield County is near the eastern edge of the Great Plains. In the western half of the county, and in the east-central part, drainageways dissect the nearly level prairie at intervals of about 1 mile. The channels of these drains are about 25 feet lower than the surrounding land. The streams flow mainly southeastward.

The northwestern and southeastern parts of the county are more rolling than the western and east-central parts. In the southwestern part, the soils are sandy and absorb most of the rain that falls. Consequently, there are few drainage channels. A few depressional areas occur in this part of the county.

The major streams of the county have flood plains up to 2 miles wide and are about 20 feet lower than the surrounding land. The stream channels within the flood plains are entrenched about 25 feet below the flood plains. The main streams draining the county are Turkey, Skeleton, Black Bear, Red Rock, and Sand Creeks. Turkey Creek drains the western half of the county, and Skeleton Creek the central part. Both of these streams flow south. Black Bear and Red Rock Creeks flow eastward and drain the eastern part of the county. Sand Creek flows northward. Turkey Creek has an elevation of 1,250 feet at its head, and an elevation of 1,107 feet at the place where it leaves the county. At the top of the watershed, the elevation of Black Bear Creek is 1,180 feet, and at the county line, 1,050.

Geology of the County [5]

Permian red beds are near the surface in Garfield County. They are overlain by only a thin veneer of Pleistocene gravel, sand, silt, clay, and volcanic ash. These red beds extend to a depth of about 1,000 feet. They dip gently westward to southwestward less than one-half degree. They belong to the Leonardian series. The youngest formation in the county, the Cedar Hills sandstone, crops out in the western part from Hillsdale through Enid to Bison. Only the lower 50 feet of this formation is exposed in Garfield County, and it forms a high escarpment. The oldest formation, the Wellington, occurs in the northeastern part of the county, about 5 miles east of Garber. Pleistocene terrace deposits of the Arkansas River system occur east of the Cedar Hills escarpment. Cimarron terrace deposits occur southwest of Enid, on top of the Cedar Hills escarpment.

The terrace deposits in this county yield moderately hard ground water at a rate of 50 to 650 gallons per minute. The red beds generally yield hard water at a rate of less than 50 gallons per minute, but the quality and quantity of this water vary extremely. The wells in the terrace deposits are generally less than 100 feet deep, and those in the red beds are less than 300 feet.

The geology of the county is shown in figure 12.

[5] This subsection and its accompanying map were prepared by ROBERT O. FAY and ROY DARIS, Geology Dept., University of Oklahoma.

Climate

Garfield County has a continental, temperate, subhumid climate typical of the red-bed plains regions of north-central Oklahoma. The area is dominated by the flow of warm, moist air masses from the Gulf of Mexico. Significant changes in temperature, precipitation, and wind occur quickly when cooler and drier air masses come from the northern regions.

The seasons are rather well defined, but changes between seasons are gradual. The winters are generally short and mild. The winter periods of cold and snow last only a few days and come when the northers push southward. Spring, most variable of the seasons, is characterized by frequent precipitation, severe storms, and tornadoes. The summers are normally hot, but the longer warm periods are eased by cool nights, pleasant breezes, and occasional heavy showers. The mild fall season alternates between sunny days and periods of moderate to soaking rains, which greatly aid pastures and winter grains.

The average annual temperature in the county is 60.8° F. The lowest temperature on record was 20° below zero in February 1905, and the highest was 118° in August 1936. Though freezing temperatures can be expected on approximately 77 days of the year, daily highs will fail to reach above freezing on only 10 of these days. During the long, warm period from March through October, temperatures reach 90° on an average of 88 days a year, and 100° on an average of 24 days.

According to the data in table 7 Garfield County's annual rate of precipitation averages 29.15 inches. Annual precipitation has ranged from a record low of 13.42 inches in 1956 to a record high of 51.46 inches in 1957. About 35 percent of the total annual precipitation occurs in summer, 30 percent in spring, 23 percent in fall, and 12 percent in winter. This distribution is favorable for crop growth and maturity. Severe thunderstorms provide hard rains during April through November. These rains usually cause quick runoff that results in crop loss, flooding, soil erosion, and loss of precipitation efficiency. Most of the dry spells occur in the winter. Since 1903, 14 indi-

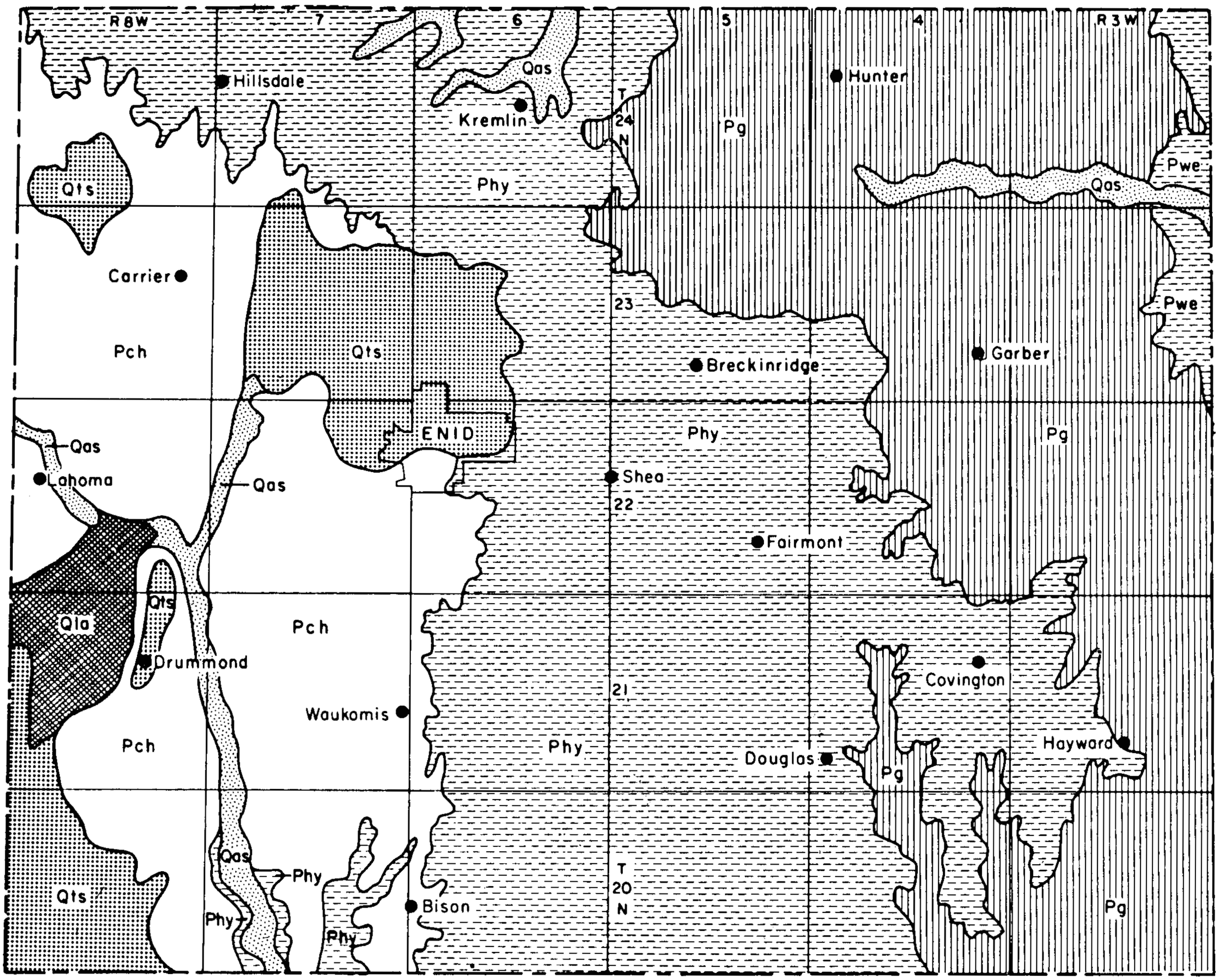


Figure 12.—Geology of Garfield County, Okla. *Qas,* alluvial deposits; *Qts,* terrace deposits; *Qla,* lacustrine deposits; *Pch,* Hennessey formation, Cedar Hills sandstone member; *Phy,* Hennessey formation, Bison banded member and Fairmont shale member; *Pg,* Garber formation; *Pwe,* Wellington formation.

vidual months have failed to receive measurable precipitation. Except for only two winters, however, measurable snow has occurred during all winters since 1903–04. During 1948–49 there was an accumulation of 30.0 inches of snow. Table 7 provides additional data on snow cover.

The average annual lake evaporation in Garfield County ranges from 60 inches in the east to 62 inches in the west. Of this amount, 70 percent occurs from May to October.

Southerly surface winds prevail over the county except late in January and in February when the shift is to north-northwesterly winds. The average wind speed is about 12.5 miles per hour, but it varies from 14.5 miles per hour during March and April to 11 miles per hour in September. Of the 21 tornadoes observed in the county during the period 1875–1962, only 3 have been major, that is, have caused damages of $50,000 or more. Hailstorms are also of concern to the farmers, since 22 of them have occurred within the county since 1924. In this total are only those storms during which hailstones were three-fourths of an inch in diameter, or larger.

The largest monthly occurrence of hailstorms has been six in June, and April and May rank second, with three each.

Sufficient growing weather for crops is the freeze-free season that averages 205 days in the northeastern part of the county and up to 215 days in the west-central part (table 8). Spring freezes (32 degrees or below) have occurred as late as May 3d, and fall freezes as early as October 2nd. Untimely freezes usually do not cause much damage because crop growth is sufficiently advanced when they occur. Unseasonably warm periods late in winter are a far greater threat. During the warm spell, winter grains advance enough to be harmed by the normal freezes that come during spring.

TABLE 7.—*Temperature and precipitation data*

[Based on data from records kept at Enid, Garfield County, Okla., for the years 1931–60]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—.		Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F	°F	°F	°F	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	47. 9	26. 8	66	9	1. 02	0. 1	2. 4	3	2
February	52. 7	30. 1	72	14	1. 20	. 3	2. 4	2	3
March	61. 1	36. 5	80	20	1. 58	. 4	3. 4	1	2
April	71. 8	47. 7	85	34	2. 93	. 7	6. 9	[1]	8
May	79. 7	57. 3	91	45	4. 37	1. 2	8. 2		
June	90. 3	67. 0	101	56	3. 86	1. 0	7. 6		
July	95. 1	71. 7	105	63	2. 76	. 2	6. 2		
August	95. 6	70. 7	107	62	3. 46	. 6	6. 7		
September	87. 0	62. 7	98	50	2. 96	. 4	5. 9		
October	75. 9	51. 5	91	38	2. 27	. 4	5. 4		
November	60. 4	37. 4	76	22	1. 43	. 0	4. 2	1	2
December	50. 7	30. 0	67	15	1. 31	. 1	3. 1	1	2
Year	72. 4	49. 1	[2] 107	[3] 3	29. 15	18. 5	40. 3	8	3

[1] Less than 0.5 day. [2] Average annual highest temperature. [3] Average annual lowest temperature.

TABLE 8.—*Probability of freezing temperatures in spring and fall*

[Based on data from records kept at Enid, Okla., for the years 1921–50]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	March 15	March 24	April 1	April 9	April 16.
2 years in 10 later than	March 7	March 17	March 26	April 4	April 11.
5 years in 10 later than	February 21	March 5	March 16	March 25	April 2.
Fall:					
1 year in 10 earlier than	February 27	November 13	November 6	October 30	October 20.
2 years in 10 earlier than	December 4	November 21	November 13	November 5	October 25.
5 years in 10 earlier than	December 17	December 7	November 25	November 15	November 3.

Literature Cited

(1) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS. 1961. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND SAMPLING AND TESTING. Ed. 8, 2 pts., illus.

(2) BALDWIN, MARK, KELLOGG, CHARLES E., AND THORP, JAMES. 1938. SOIL CLASSIFICATION. U.S. Dept. Agr. Ybk.: 979–1001.

(3) SIMONSON, ROY W. 1962. SOIL CLASSIFICATION IN THE UNITED STATES. Sci. 137: 1027–1034.

(4) THORP, JAMES, AND SMITH, GUY D. 1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117–126.

(5) U.S. DEPT. OF AGRICULTURE. 1951. SOIL SURVEY MANUAL. U.S. Dept. Agr. Handb. 18, 503 pp., illus.

(6) U.S. DEPT OF AGRICULTURE. 1960. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM. Soil Survey Staff, 265 pp., illus. (Supplement issued in March 1967.)

(7) WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS. 1953. THE UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. No. 3-357. 2 v. and appendix (Revised 1957).

Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous soil. A soil containing enough calcium carbonate to effervesce (fizz) when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. In engineering, the fine-grained soil particles less than 0.005 millimeter in diameter.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Clay film (clay skin). A thin coating of clay on the surface of a soil aggregate.

Concretions. Hard grains, pellets, or nodules of various sizes, shapes, and colors; consist of concentrations of calcium carbonate, iron oxide, or other chemical compounds and the soil grains these compounds hold together.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are as follows:

Loose.—Noncoherent; will not hold together in a mass.

Friable.—When moist, crushes easily under gentle to moderate pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a wire when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material; tends to stretch somewhat and pull apart, rather than pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Deflocculation. Dispersion, or breaking up, of soil aggregates into individual particles. Sodium salts, for example, deflocculate, or disperse, granulated particles of clay to form a clay that runs together, or puddles.

Eolian soil material. Windblown silts and fine sands.

Humus. The well-decomposed, more or less stable part of the organic matter in mineral soils.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by the height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium, rapid,* and *very rapid.*

Loam. Soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Loess. A fine-grained eolian deposit consisting dominantly of silt-sized particles.

Mapping unit. Any soil, miscellaneous land type, soil complex, or undifferentiated soil group shown on the detailed soil map and identified by a symbol.

Miscellaneous land type. A mapping unit for areas of land that have little or no natural soil; or that are too nearly inaccessible for orderly examination; or that occur where, for other reasons, it is not feasible to classify the soil.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and impeded drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.*

Natural drainage. Refers to conditions that existed during the development of a soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free of mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Imperfectly or somewhat poorly drained soils are wet for significant periods but not all the time, and in podzolic soils commonly have mottlings below 6 to 16 inches in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent, or nearly so, in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.* The permeability of a soil may be limited by one nearly impermeable horizon, even though the other horizons are permeable.

Phase, soil. A subdivision of a soil type, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil type, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects management.

Profile, soil. A vertical section of the soil through all its horizons, or layers, and extending into the underlying material. The main horizons in a soil profile are designated O, A, B, C, and R. The O horizon refers to organic material above the mineral soil; the A horizon is roughly approximate to surface soil; the B horizon is subsoil; the C horizon is the unconsolidated material under the subsoil; and the R horizon is bedrock.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Relief. The elevations or inequalities of the land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular clevage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer below the solum, or true soil. The C or R horizon.

Surface layer. The layer at the surface, regardless of its depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace. An old alluvial plain, ordinarily flat or undulating, bordering a stream. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. A terrace dissected by streams may be more or less hilly, but it is still regarded as a terrace.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Water-holding capacity. The capacity of a soil to hold water in a form available to plants. The amount of moisture held in a soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension. Also termed "available moisture capacity," "available water capacity," "moisture-holding capacity."

Winnowing. Removal of clay and silt particles from the soil by strong winds. The coarser particles remain, and the soil becomes sandier and more highly erodible as the process continues.

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at (800) 457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

Nondiscrimination Statement

Nondiscrimination Policy

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, whether all or part of an individual's income is derived from any public assistance program, or protected genetic information. The Department prohibits discrimination in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

To File an Employment Complaint

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (http://directives.sc.egov.usda.gov/33081.wba) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for

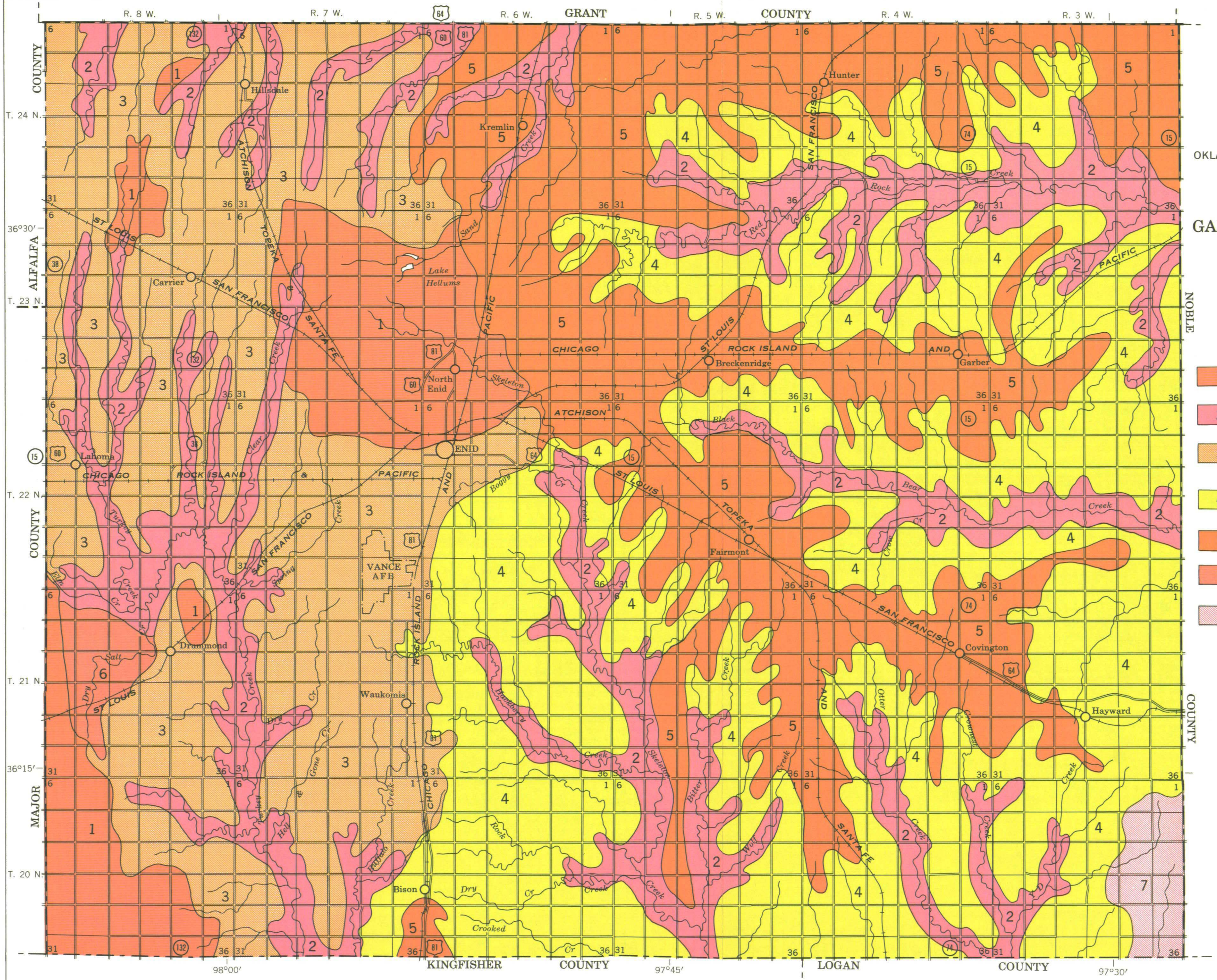
program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Supplemental Nutrition Assistance Program

For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (http://directives.sc.egov.usda.gov/33085.wba).

All Other Inquiries

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (http://directives.sc.egov.usda.gov/33086.wba).



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
OKLAHOMA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
GARFIELD COUNTY, OKLAHOMA

Scale 1:190,080

1 0 1 2 3 4 Miles

SOIL ASSOCIATIONS

1 Pratt-Carwile-Shellabarger association: Deep, sandy, and loamy, level to gently sloping soils of the uplands

2 Port-Reinach association: Deep, nearly level, loamy soils of the flood plains

3 Grant-Pond Creek association: Deep, loamy, nearly level to moderately steep soils of the uplands

4 Renfrow-Vernon-Kirkland association: Deep and shallow, nearly level to gently sloping upland soils with a clayey subsoil

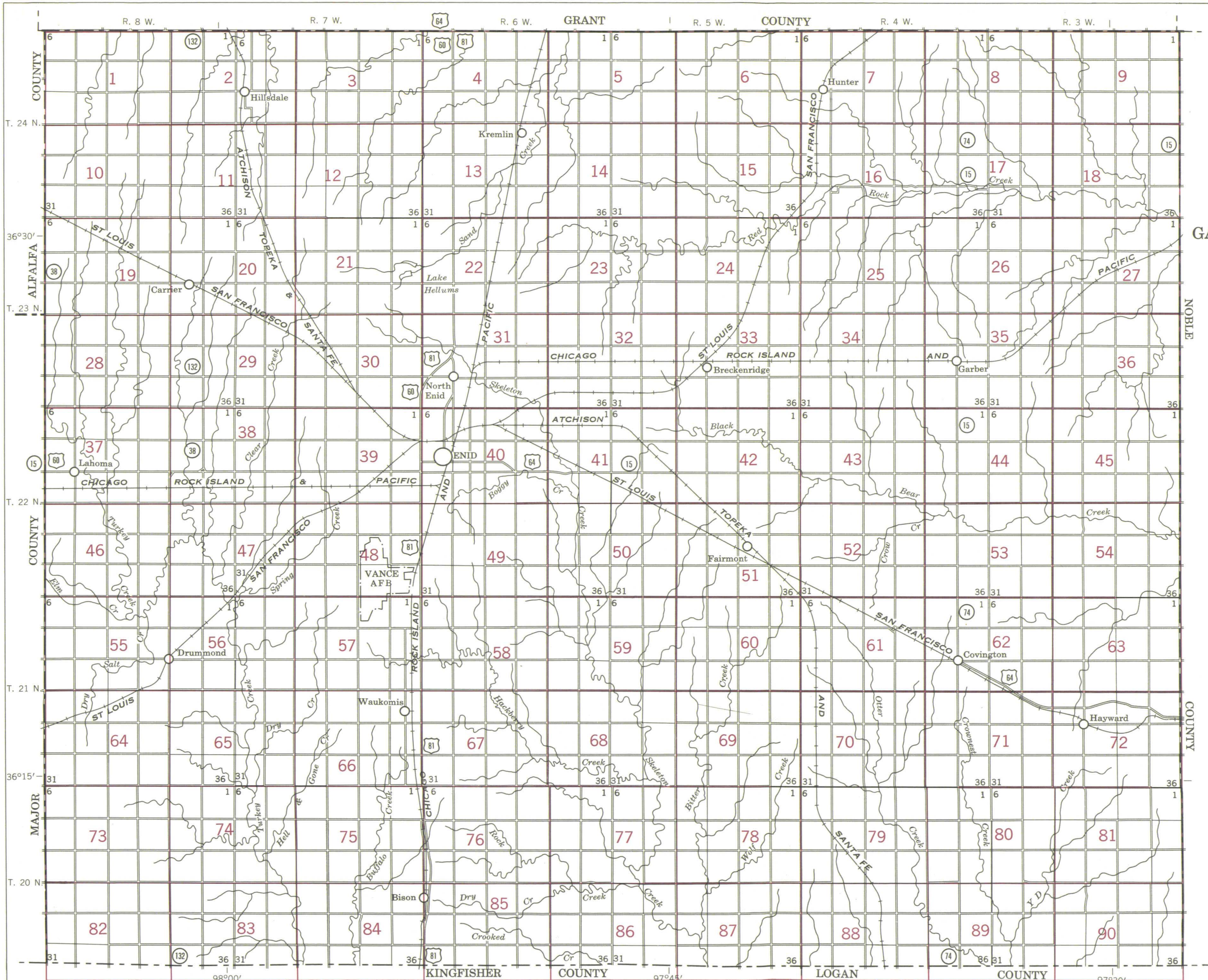
5 Kirkland-Bethany-Tabler association: Deep, nearly level, loamy soils of the uplands

6 Drummond-Miller association: Deep, nearly level soils of the bottom lands

7 Zaneis-Lucien-Vernon association: Deep and shallow, very gently to steeply sloping soils of the uplands

November 1966

N



INDEX TO MAP SHEETS
GARFIELD COUNTY, OKLAHOMA

Scale 1:190,080

1 0 1 2 3 4 Miles

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, or E, shows the slope. Most symbols without a slope letter are those of soils or land types that are nearly level, but some are for soils or land types that have a considerable range of slope. A final number, 2, in the symbol shows that the soil is eroded.

SYMBOL	NAME
BeA	Bethany silt loam, 0 to 1 percent slopes
Bk	Breaks–Alluvial land complex
Br	Broken alluvial land
Ca	Carwile loam
Dr	Drummond soils
Ec	Eroded clayey land
GaA	Grant silt loam, 0 to 1 percent slopes
GaB	Grant silt loam, 1 to 3 percent slopes
GaC	Grant silt loam, 3 to 5 percent slopes
GaC2	Grant silt loam, 3 to 5 percent slopes, eroded
GnD	Grant–Nash silt loams, 5 to 8 percent slopes
GnD2	Grant–Nash silt loams, 5 to 8 percent slopes, eroded
GnE	Grant–Nash silt loams, 8 to 20 percent slopes
GnE2	Grant–Nash silt loams, 8 to 20 percent slopes, eroded
KfB	Kingfisher silt loam, 1 to 3 percent slopes
KfC2	Kingfisher silt loam, 2 to 5 percent slopes, eroded
KlD2	Kingfisher–Lucien complex, 5 to 8 percent slopes, eroded
KnA	Kirkland silt loam, 0 to 1 percent slopes
KrB	Kirkland–Renfrow silt loams, 1 to 3 percent slopes
KsA	Kirkland–Slickspots complex, 0 to 1 percent slopes
LuC	Lucien very fine sandy loam, 3 to 5 percent slopes
MeB	Meno loamy fine sand, undulating
Mr	Miller clay
Ms	Miller–Slickspots complex
NaB	Nash silt loam, 1 to 3 percent slopes
NaC	Nash silt loam, 3 to 5 percent slopes
NoB	Norge loam, 1 to 3 percent slopes
NoC	Norge loam, 3 to 5 percent slopes
NoC2	Norge loam, 3 to 5 percent slopes, eroded
NoD	Norge loam, 5 to 8 percent slopes
NoD2	Norge loam, 5 to 8 percent slopes, eroded
PcA	Pond Creek silt loam, 0 to 1 percent slopes
PcB	Pond Creek silt loam, 1 to 3 percent slopes
Po	Port clay loam
PrA	Port silt loam, 0 to 1 percent slopes
PrB	Port silt loam, 1 to 3 percent slopes
PsB	Pratt loamy fine sand, undulating
PtC	Pratt loamy fine sand, hummocky
Pu	Pulaski fine sandy loam
Rc	Reinach loam
Re	Reinach–Slickspots complex
RfA	Renfrow clay loam, 0 to 1 percent slopes
RfB	Renfrow clay loam, 1 to 3 percent slopes
RsC	Renfrow silt loam, 3 to 5 percent slopes
RvC2	Renfrow–Vernon complex, 3 to 5 percent slopes, eroded
ShA	Shellabarger fine sandy loam, 0 to 1 percent slopes
ShB	Shellabarger fine sandy loam, 1 to 3 percent slopes
SrB	Shellabarger–Carwile fine sandy loams, undulating
TaA	Tabler silt loam, 0 to 1 percent slopes
VcC2	Vernon clay loam, 3 to 5 percent slopes, eroded
VrD	Vernon soils, 5 to 12 percent slopes
Vs	Vernon soils and Rock outcrop
WoB	Weymouth–Ost loams, undulating
ZaB	Zaneis loam, 1 to 3 percent slopes
ZaC	Zaneis loam, 3 to 5 percent slopes
ZaC2	Zaneis loam, 3 to 5 percent slopes, eroded

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry (FY)
- Ford
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries
- Mine dump
- Pits, gravel or other

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

BOUNDARIES

- National or state
- County
- Township or range, U. S.
- Section line, corner, U. S.
- Reservation
- Land grant
- Small park, cemetery, airport

DRAINAGE

Streams
- Perennial
- Intermittent, unclassified
- Crossable with tillage implements

Canals and ditches (CANAL, DITCH)

Lakes and ponds
- Perennial
- Intermittent

Wells, water (flowing)

Springs

Marsh

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stones
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully

Soil map constructed 1966 by Cartographic Division, Soil Conservation Service, USDA, from 1961 aerial photographs. Controlled mosaic based on Oklahoma plane coordinate system, north zone, Lambert conformal conic projection, 1927 North American datum.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

R. 8 W. | R. 7 W.

(Joins sheet 2)

N

T. 24 N.

(Joins sheet 10)

(Joins sheet 12)

(Joins sheet 20)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

R. 6 W.

(Joins sheet 4)

13

N

T. 24 N.

(Joins sheet 12)

(Joins sheet 14)

(Joins sheet 22)

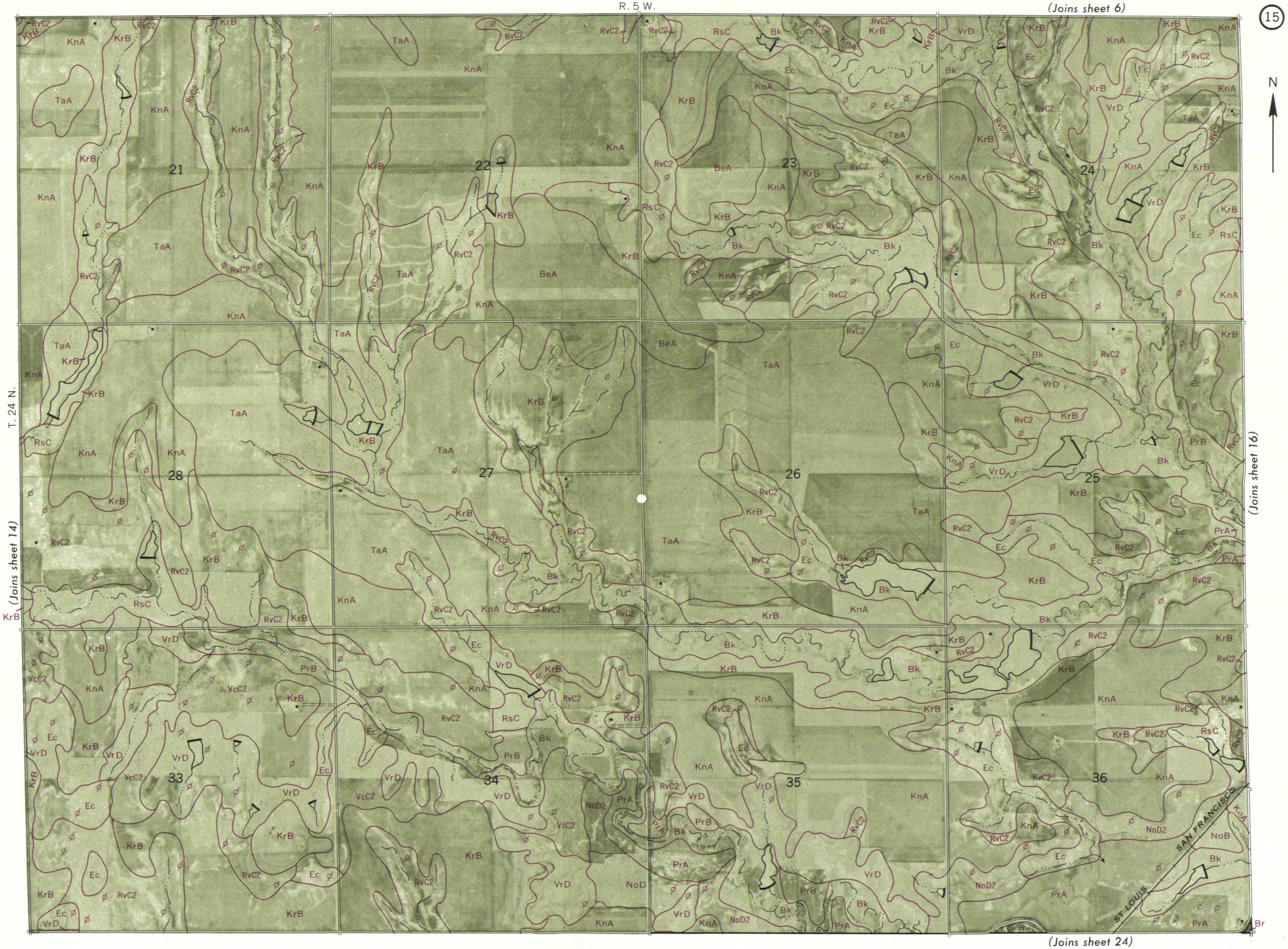
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

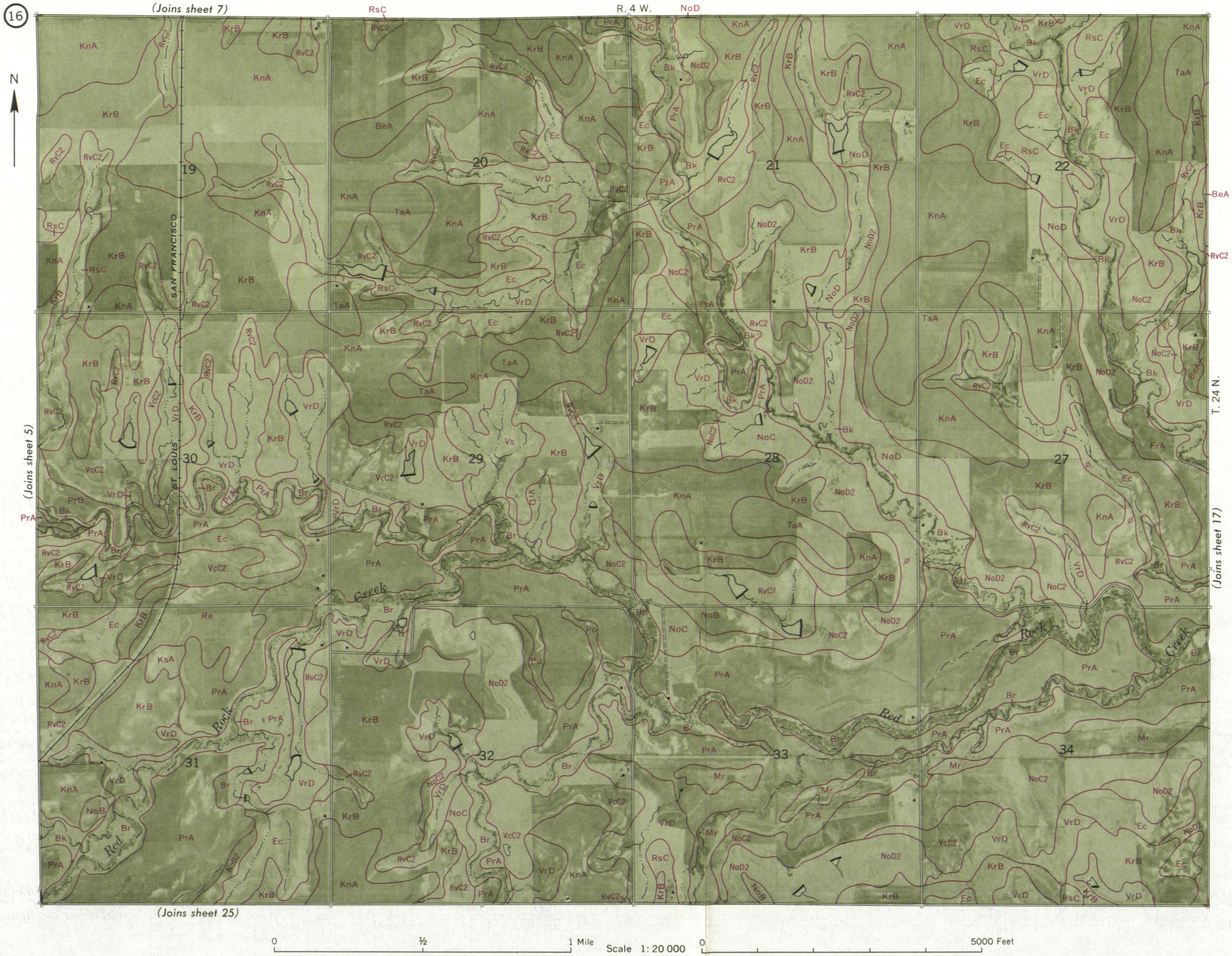
GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 15



This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet


16
(Joins sheet 7)
R. 4 W.
N
(Joins sheet 5)
(Joins sheet 17)
T. 24 N.
(Joins sheet 25)
SAN FRANCISCO
ST. LOUIS
Rock Creek
Red Rock Creek
19
20
21
22
30
29
28
27
31
32
33
34
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

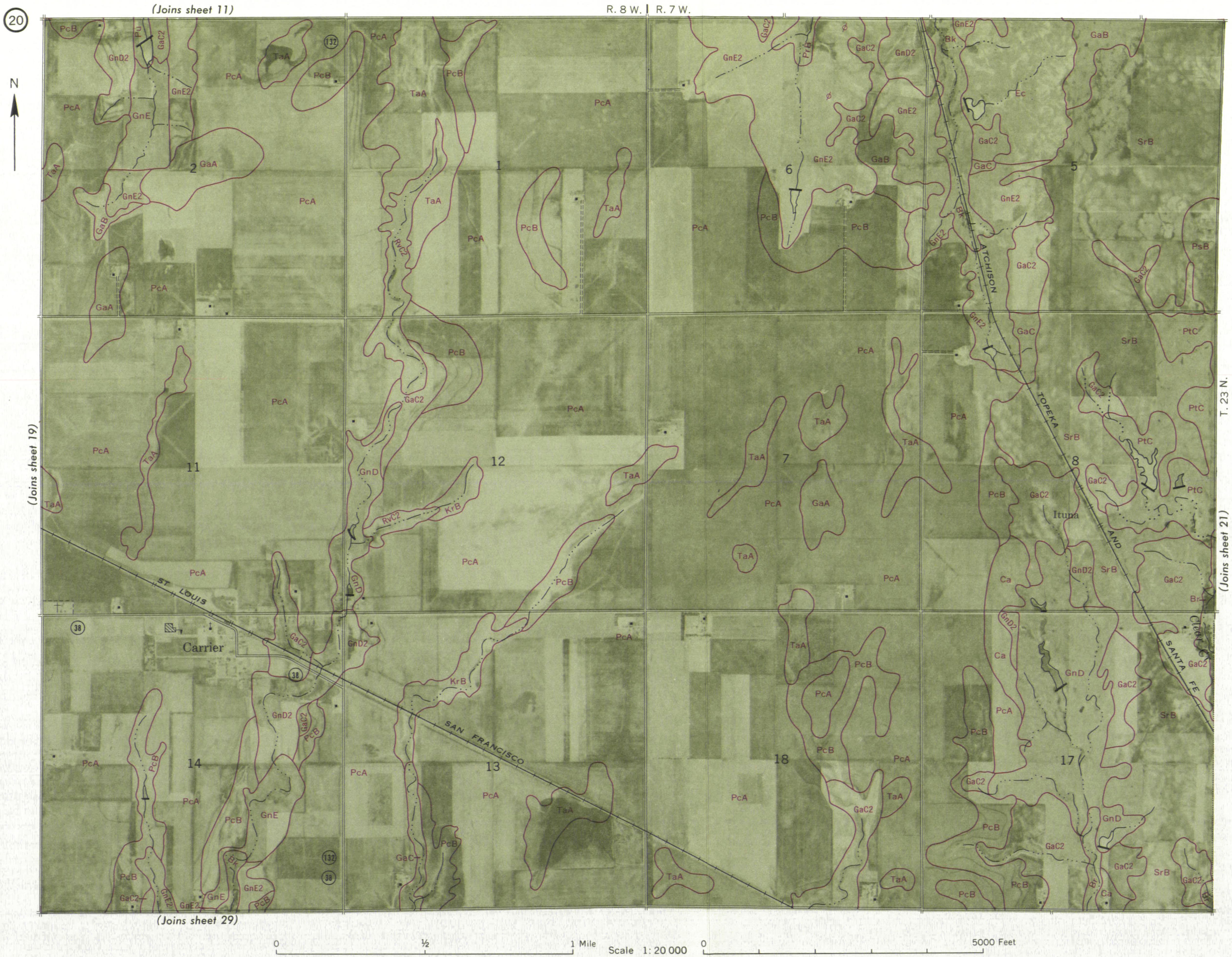

18
(Joins sheet 9)
R. 3 W.
N
(Joins sheet 17)
T. 24 N.
NOBLE COUNTY
(Joins sheet 27)
21
22
23
24
28
27
26
25
33
34
35
36
15
Red Rock Creek
0 ½ 1 Mile
Scale 1: 20 000
0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

2

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet


20
(Joins sheet 11)
R. 8 W. | R. 7 W.
N
(Joins sheet 19)
(Joins sheet 21)
T. 23 N.
(Joins sheet 29)
Carrier
Ituna
ST LOUIS SAN FRANCISCO
ATCHISON TOPEKA AND SANTA FE
1
2
5
6
7
8
11
12
13
14
17
18
0 ½ 1 Mile
Scale 1:20 000
0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 22

(22)

(Joins sheet 13)

R. 6 W.

N

(Joins sheet 21)

T. 23 N.

(Joins sheet 23)

(Joins sheet 31)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

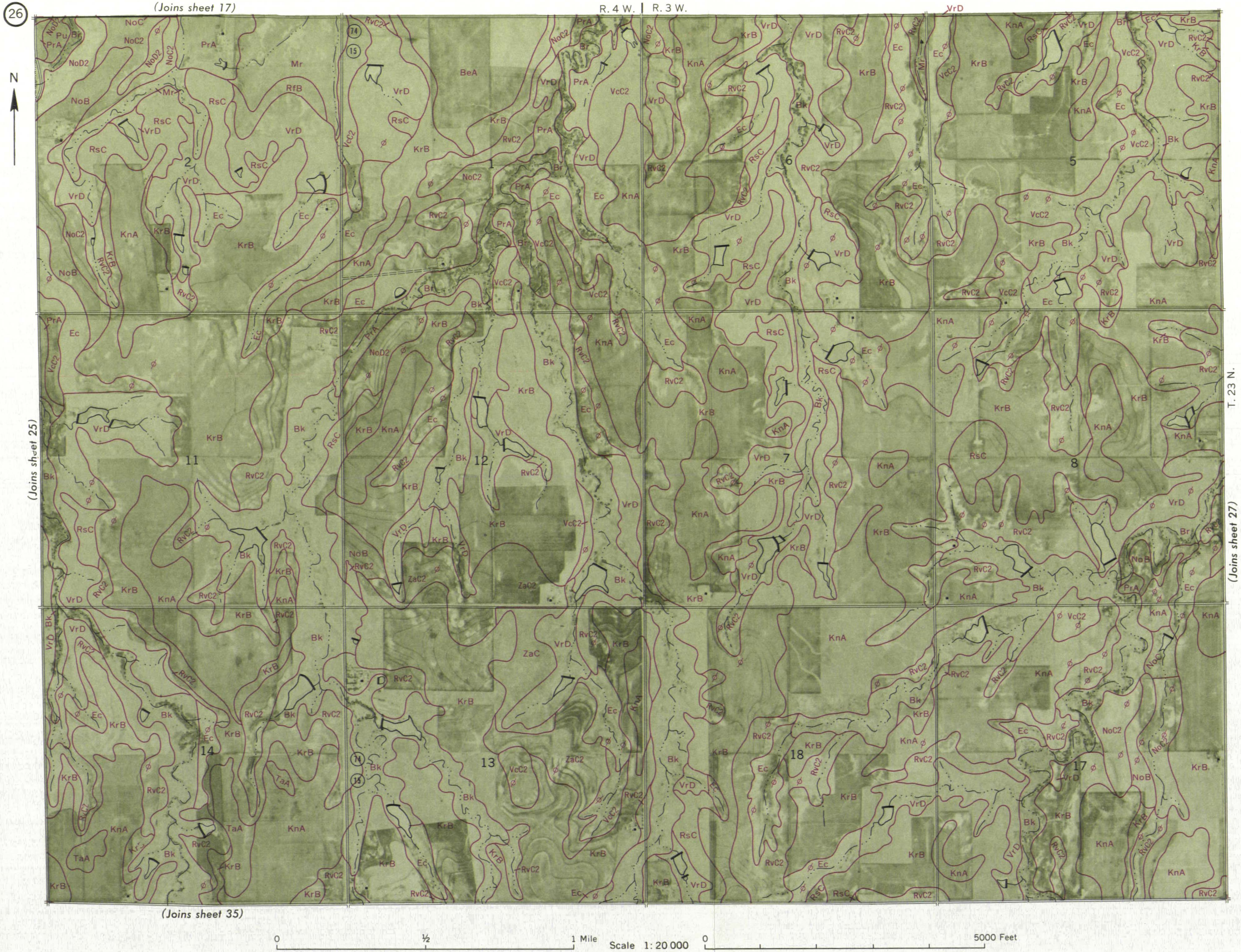
Range, township, and section corners shown on this map are indefinite.


24
(Joins sheet 14)
R. 5 W.
N
(Joins sheet 23)
(Joins sheet 25)
T. 23 N.
(Joins sheet 33)
Red Rock Creek
ST. LOUIS SAN FRANCISCO
1
2
3
4
9
10
11
12
13
14
15
16
0 ½ 1 Mile
Scale 1: 20 000
0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.


26
(Joins sheet 17)
R. 4 W.
R. 3 W.
N
(Joins sheet 25)
(Joins sheet 27)
T. 23 N.
(Joins sheet 35)
1
2
5
6
7
8
11
12
13
14
17
18
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

R. 3 W.

(Joins sheet 18)

27

N

T. 23 N.

(Joins sheet 26)

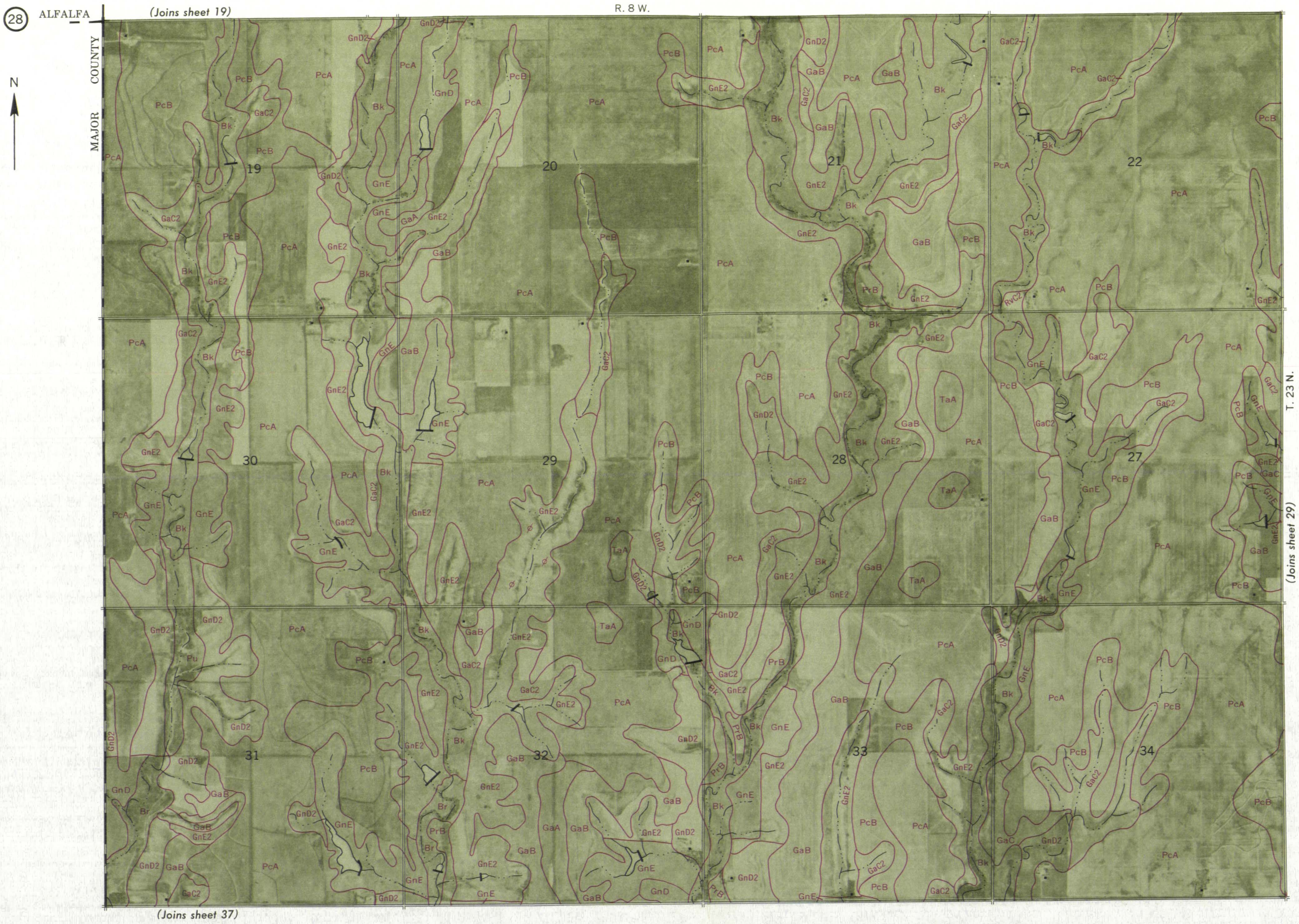
NOBLE COUNTY

(Joins sheet 36)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



Scale 1: 20 000

0 ½ 1 Mile

0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

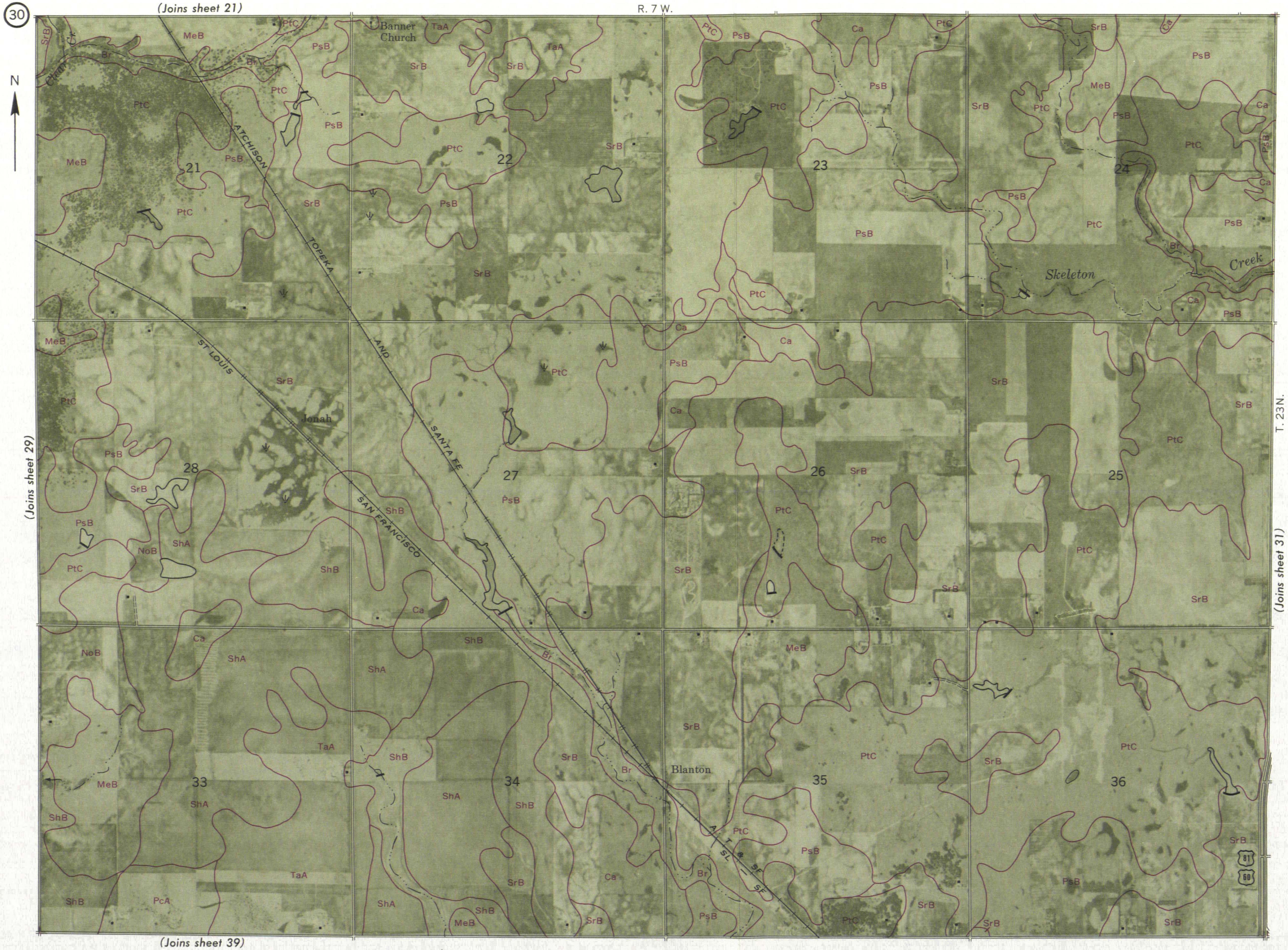
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

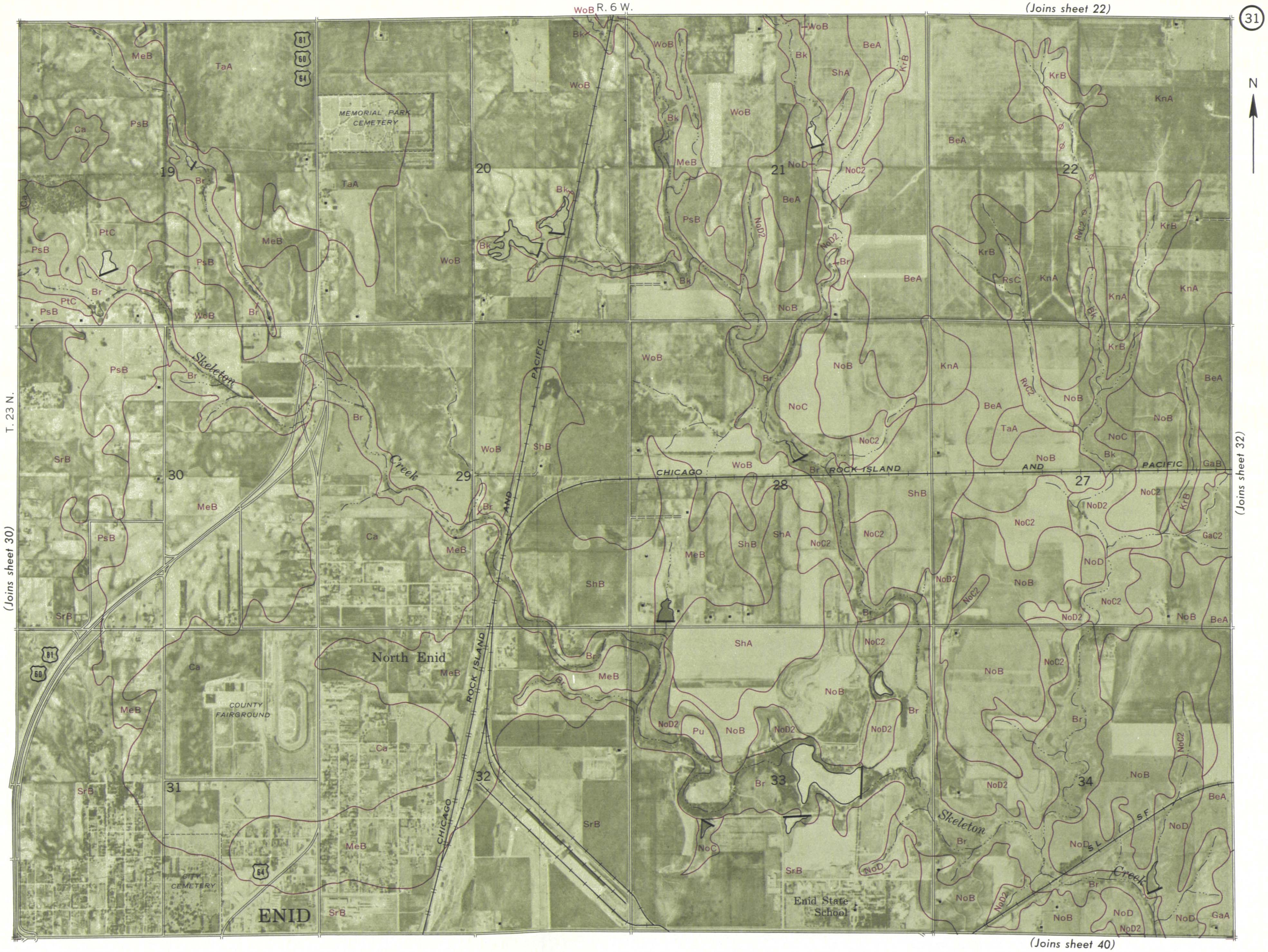
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

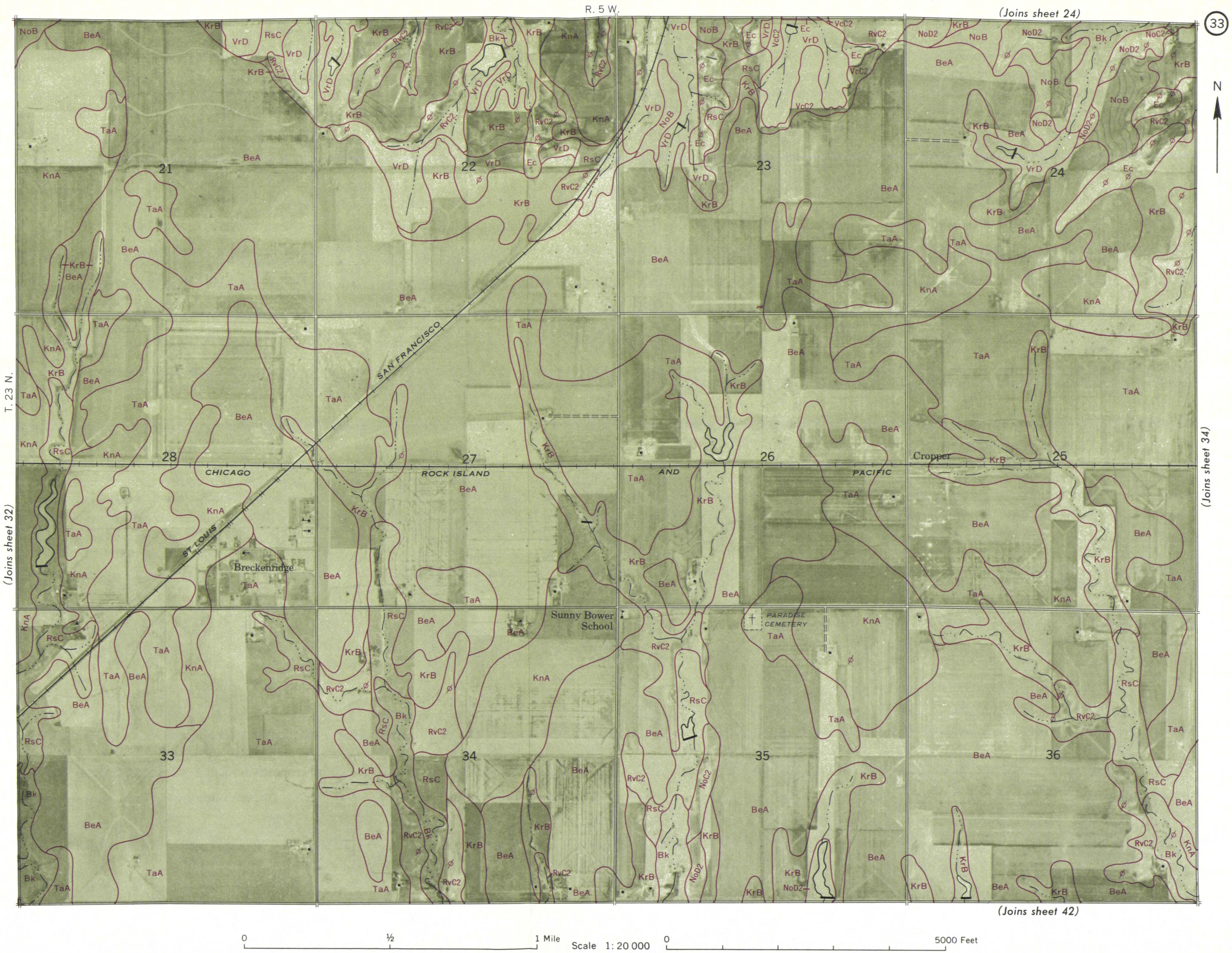


0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

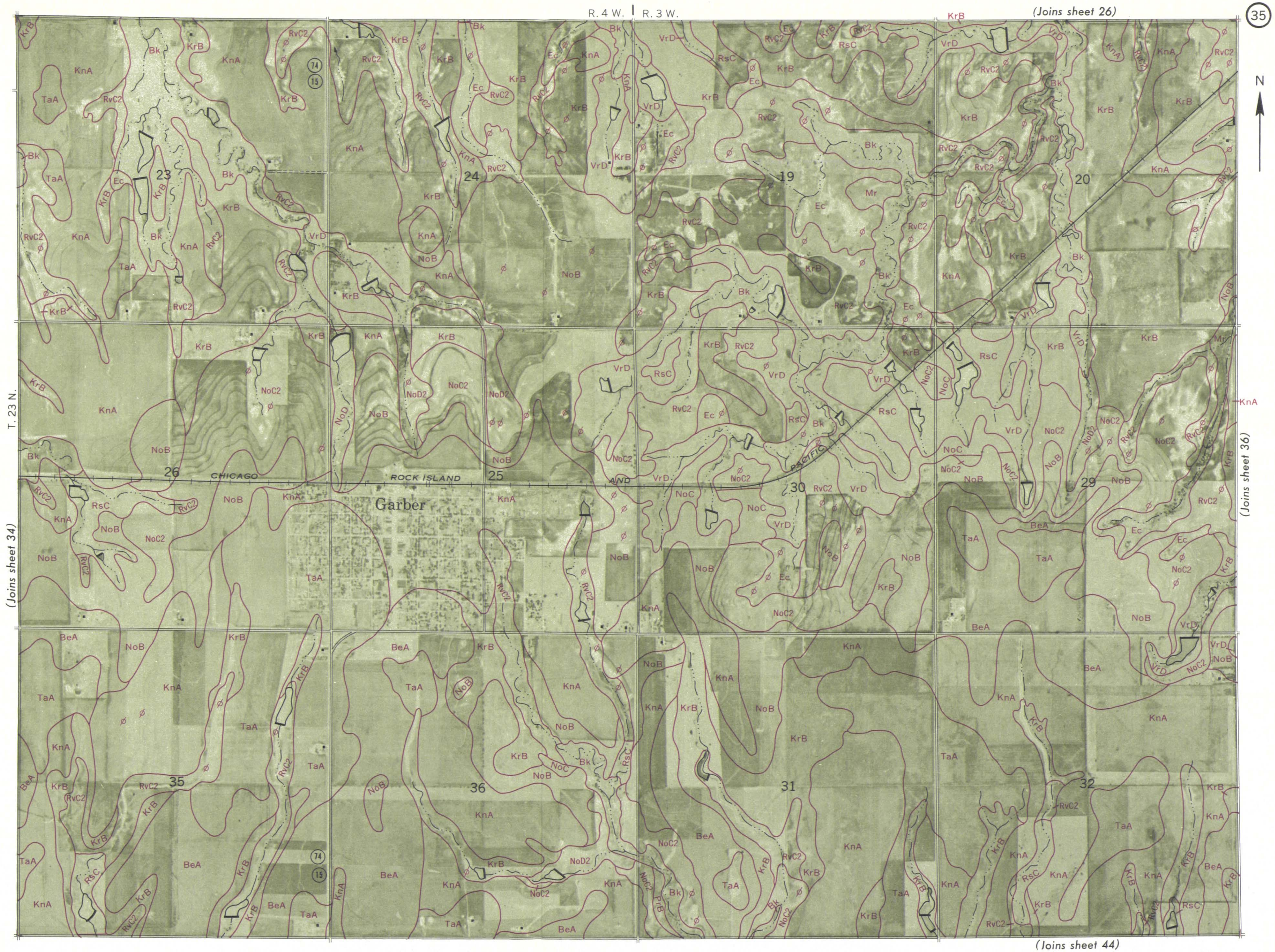
Range, township, and section corners shown on this map are indefinite.

34

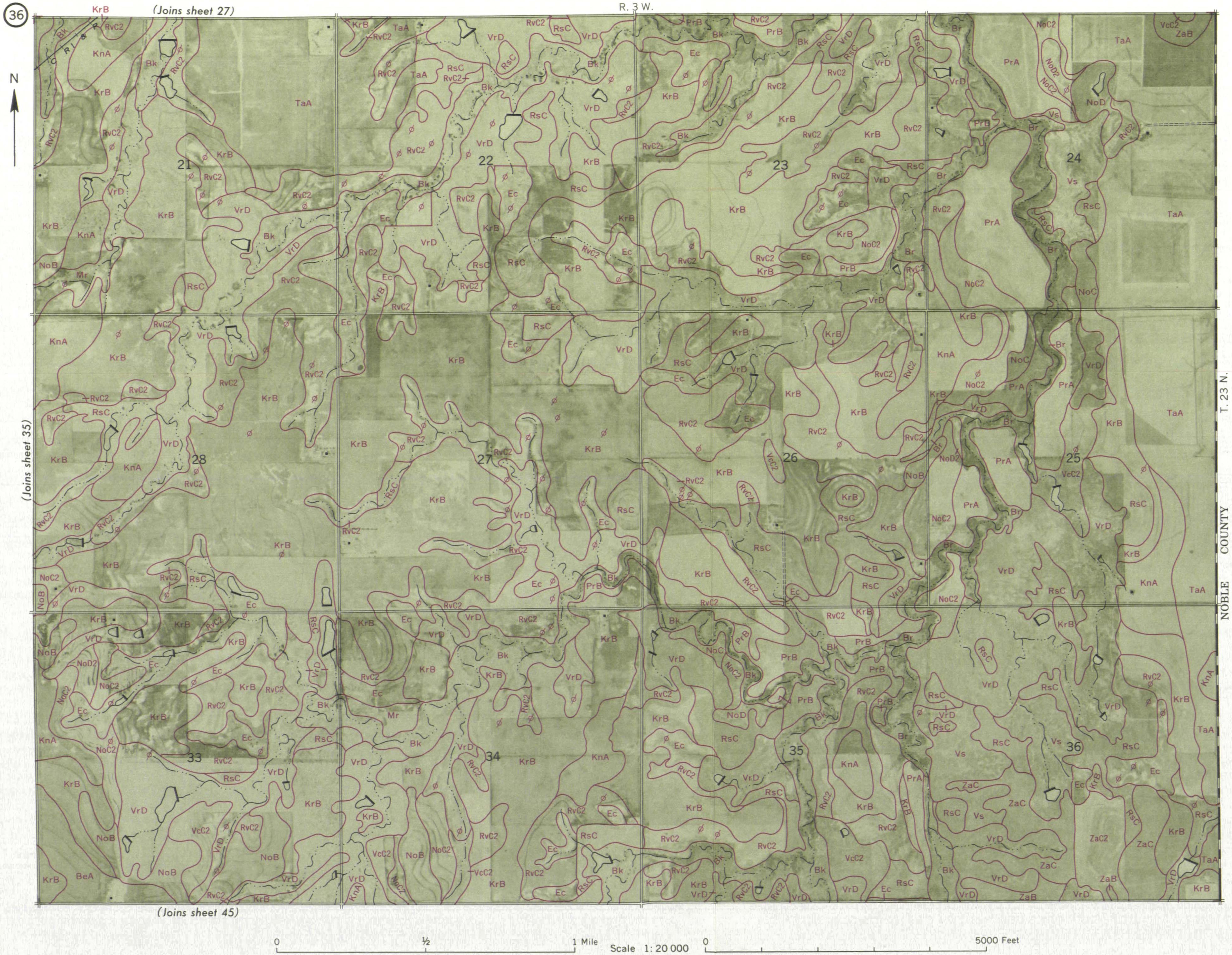
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

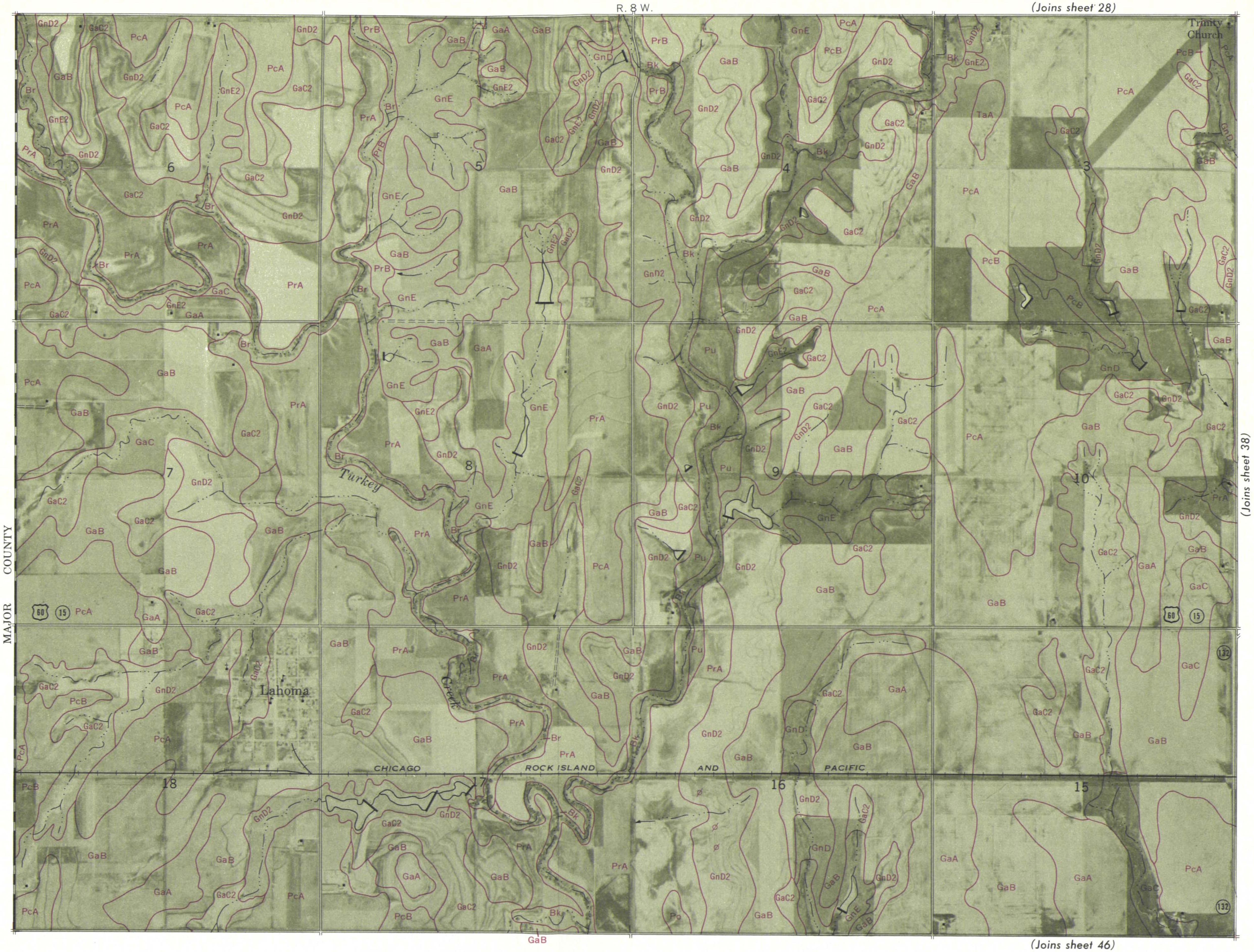
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet


36
(Joins sheet 27)
R. 3 W.
N
(Joins sheet 35)
T. 23 N.
NOBLE COUNTY
(Joins sheet 45)
21
22
23
24
28
27
26
25
33
34
35
36
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

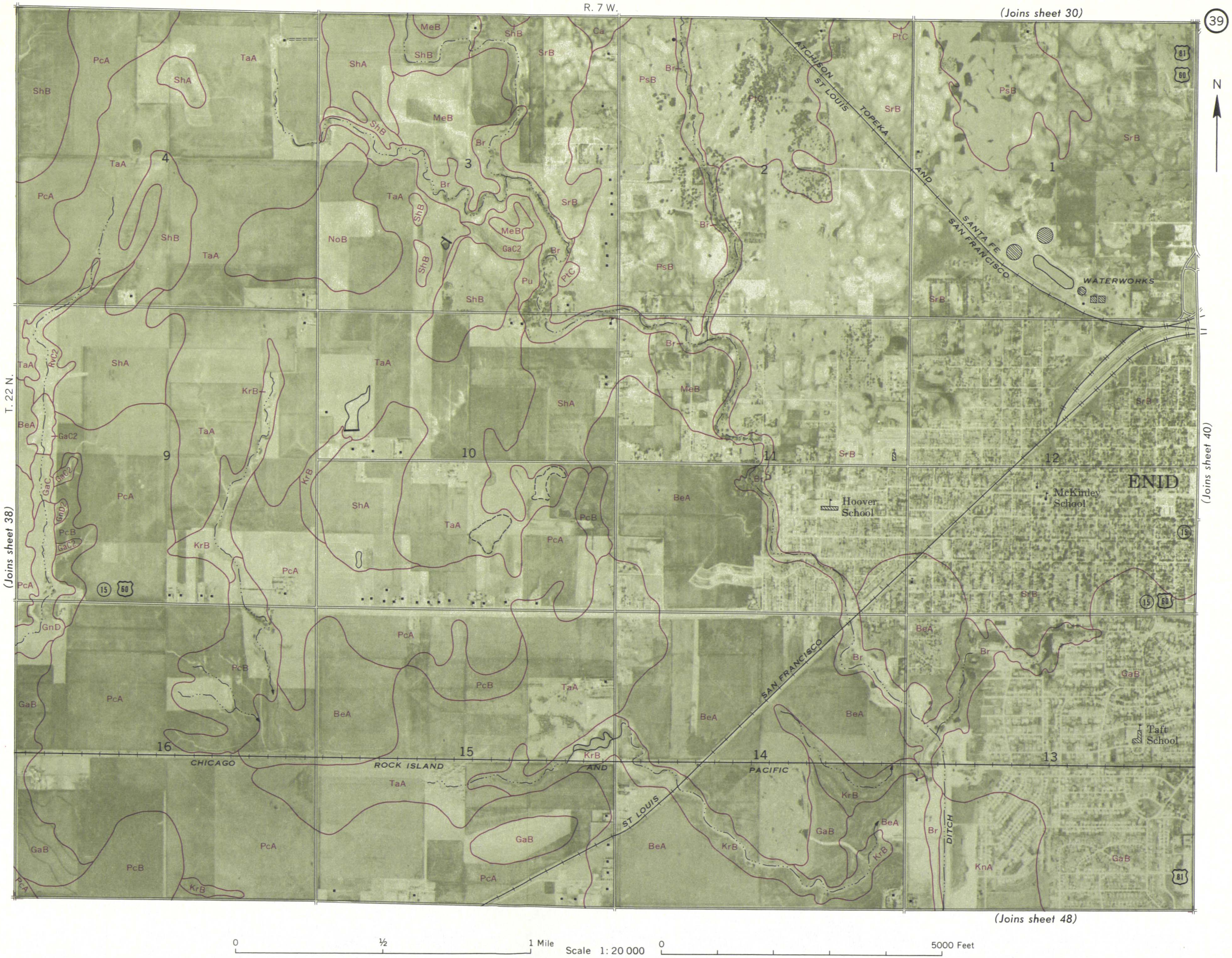


0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile

Scale 1: 20 000

0 5000 Feet


42
(Joins sheet 33)
R. 5 W.
T. 22 N.
(Joins sheet 41)
(Joins sheet 43)
(Joins sheet 51)
N
Black Bear Creek
ATCHISON TOPEKA AND SANTA FE
1 2 3 4 9 10 11 12 13 14 15 16
0 ½ 1 Mile
Scale 1: 20 000
0 5000 Feet

43

R. 4 W.

(Joins sheet 34)

T. 22 N.

(Joins sheet 42)

(Joins sheet 44)

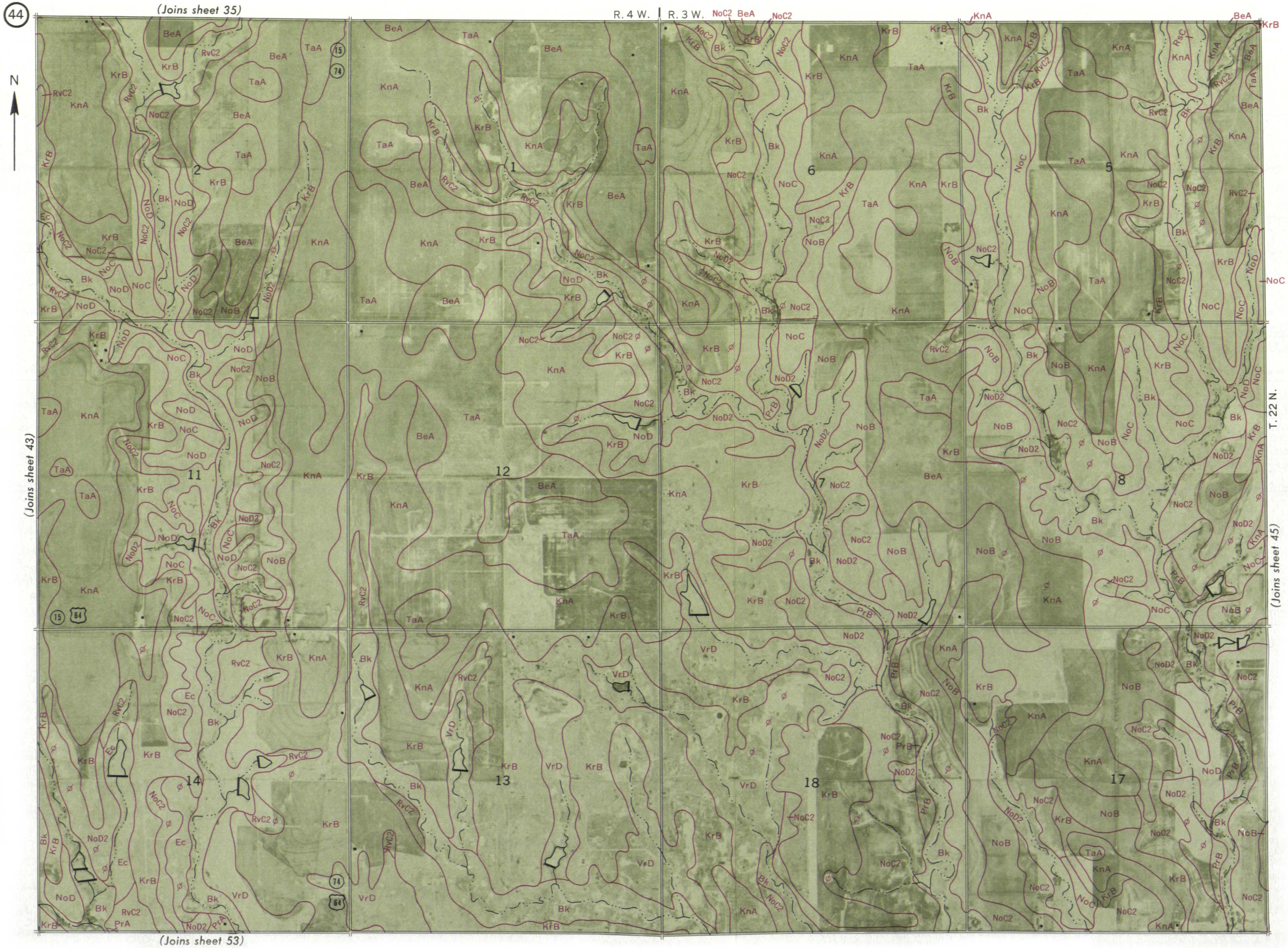
(Joins sheet 52)

KrB RvC2 VrD

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

46

(Joins sheet 37)

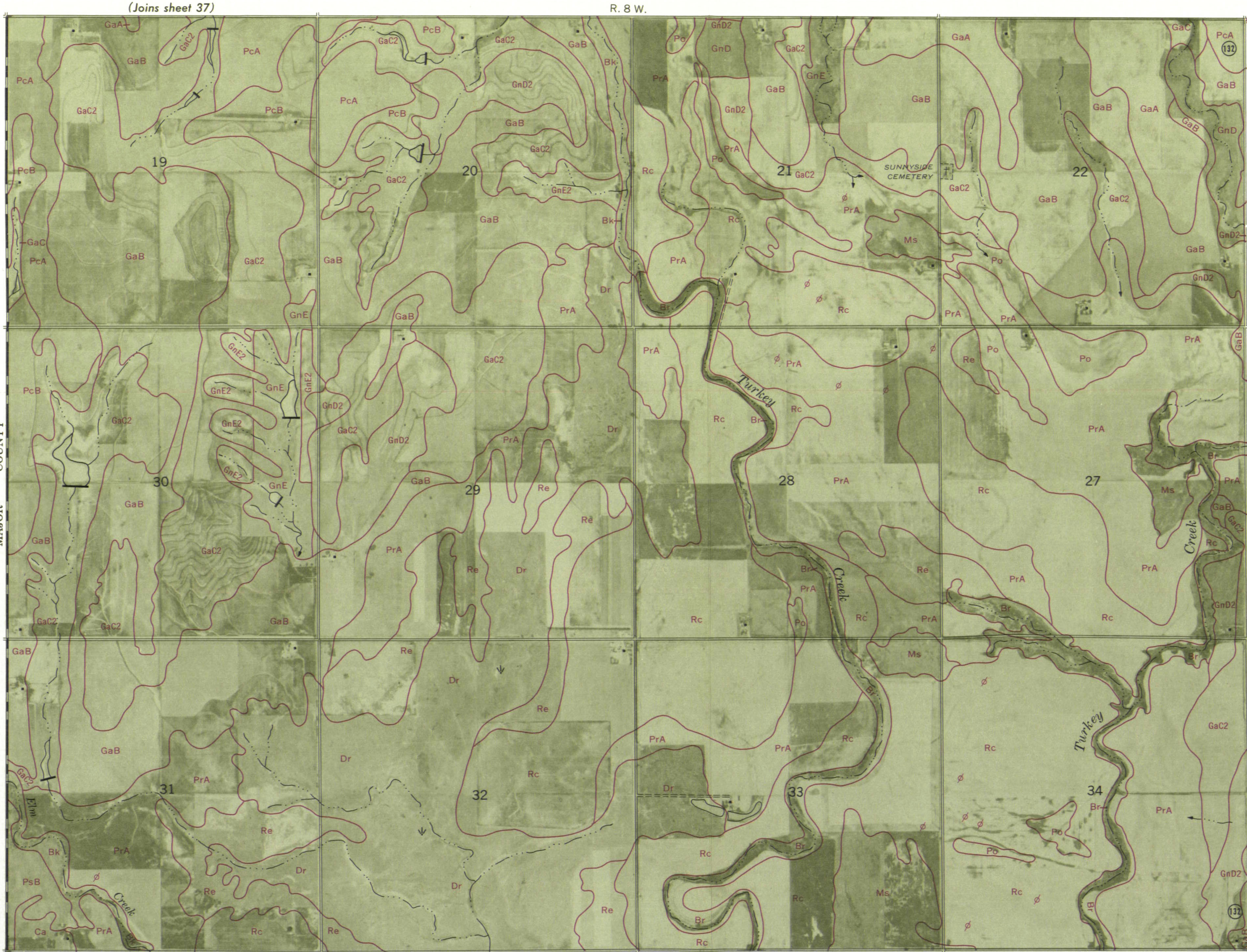
R. 8 W.

N

MAJOR COUNTY

T. 22 N.

(Joins sheet 47)



(Joins sheet 55)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

R. 8 W. | R. 7 W.

(Joins sheet 38)

47

(Joins sheet 46)

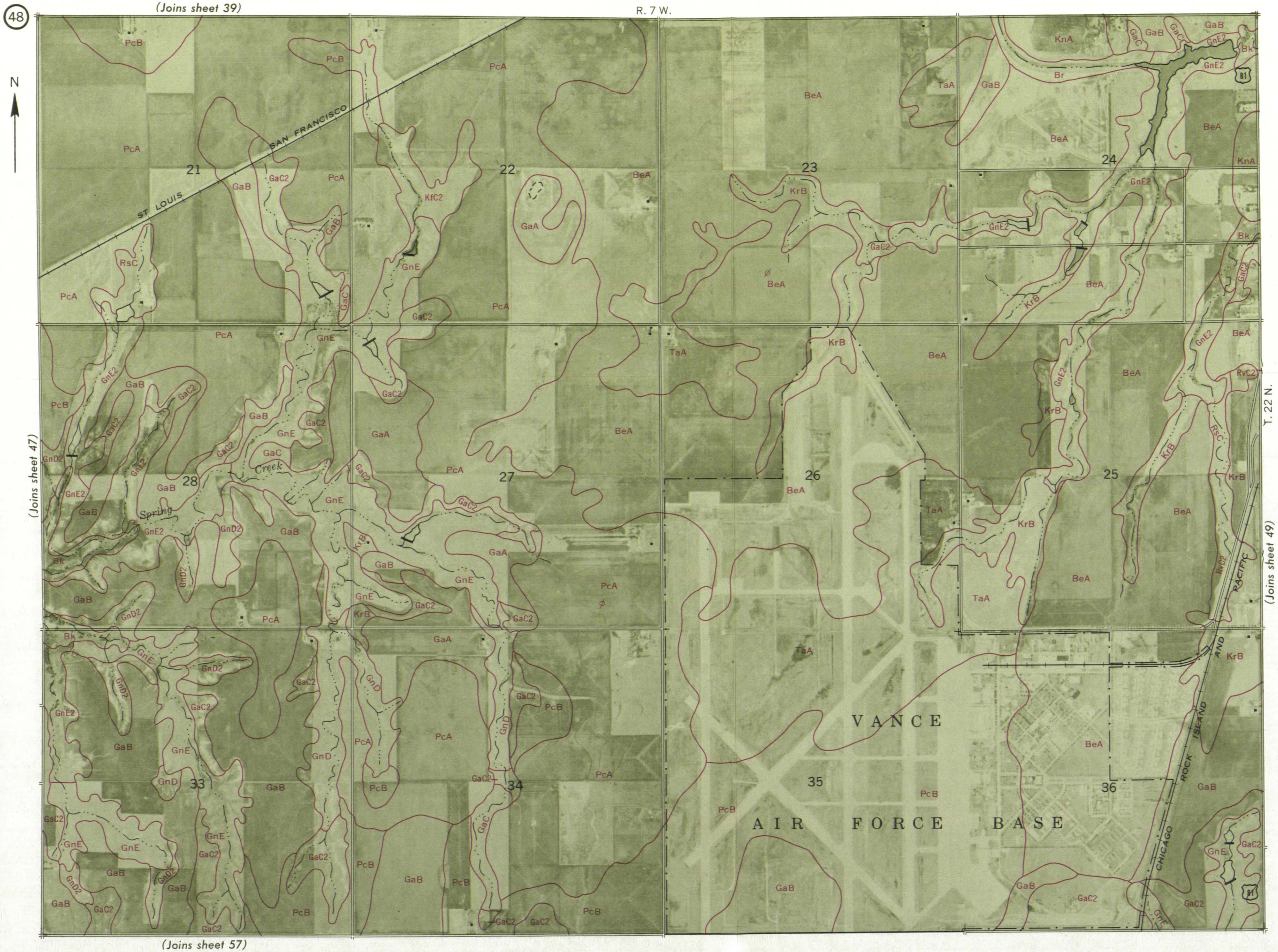
(Joins sheet 48)

(Joins sheet 56)

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

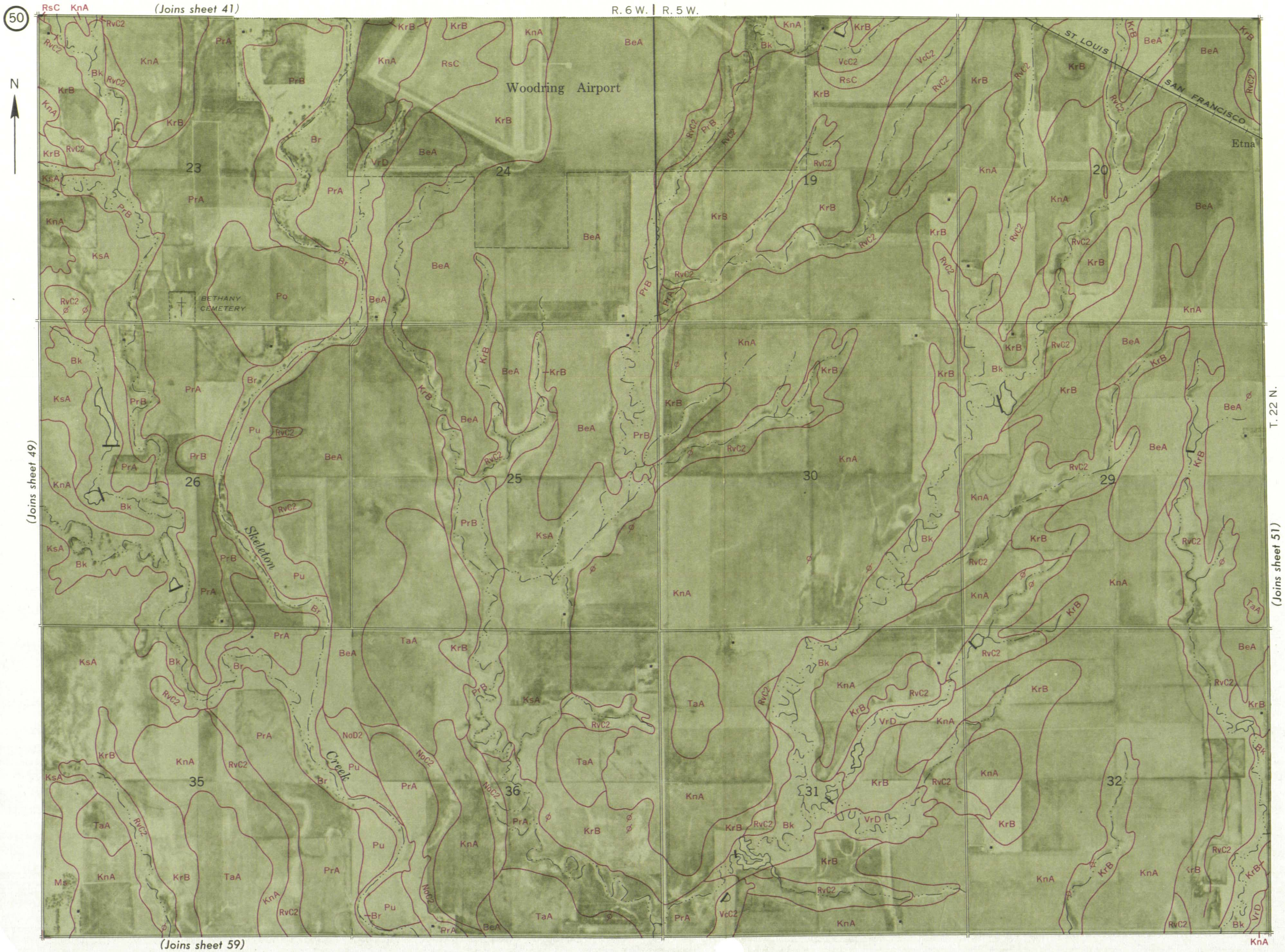
Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

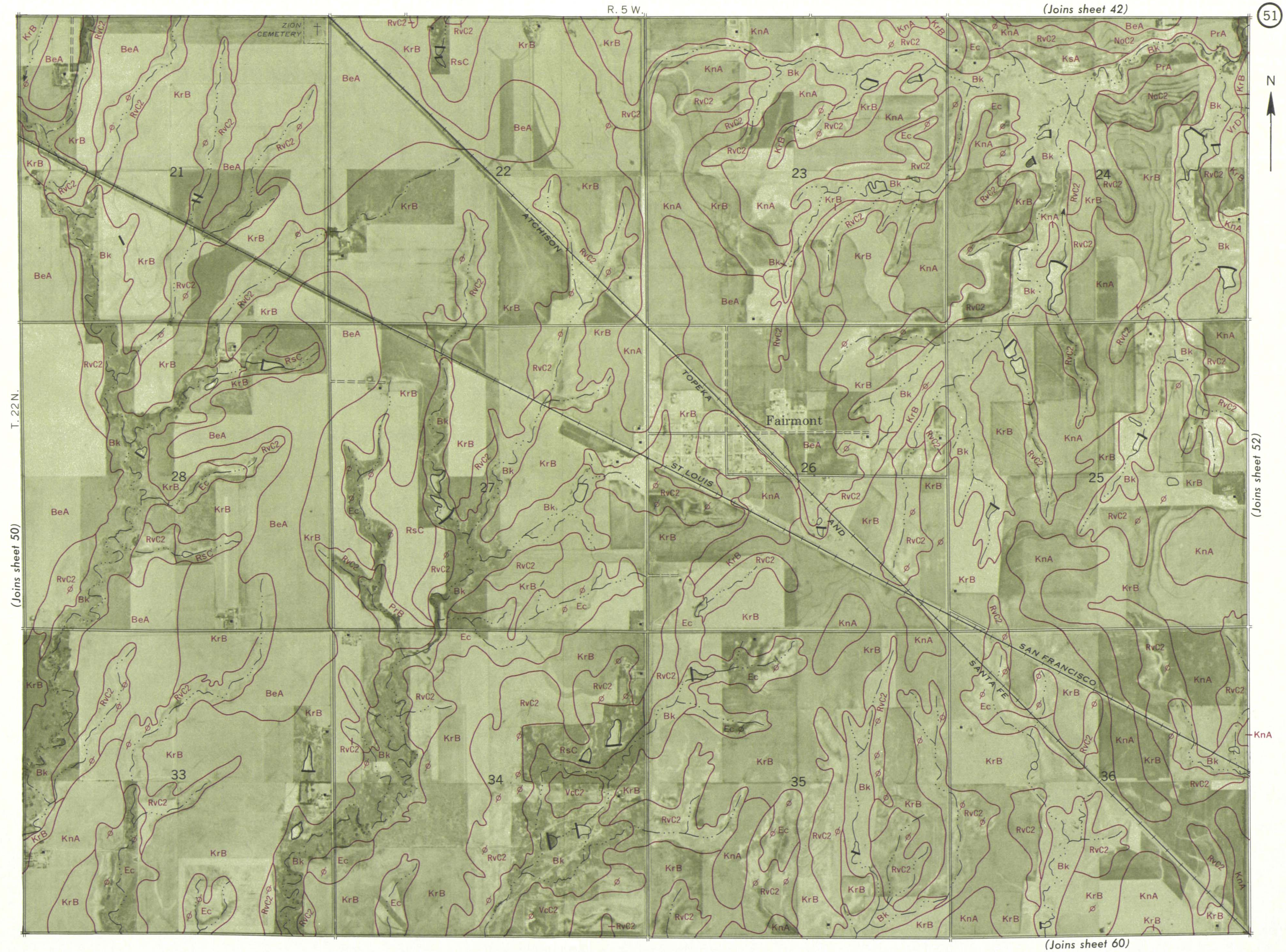
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

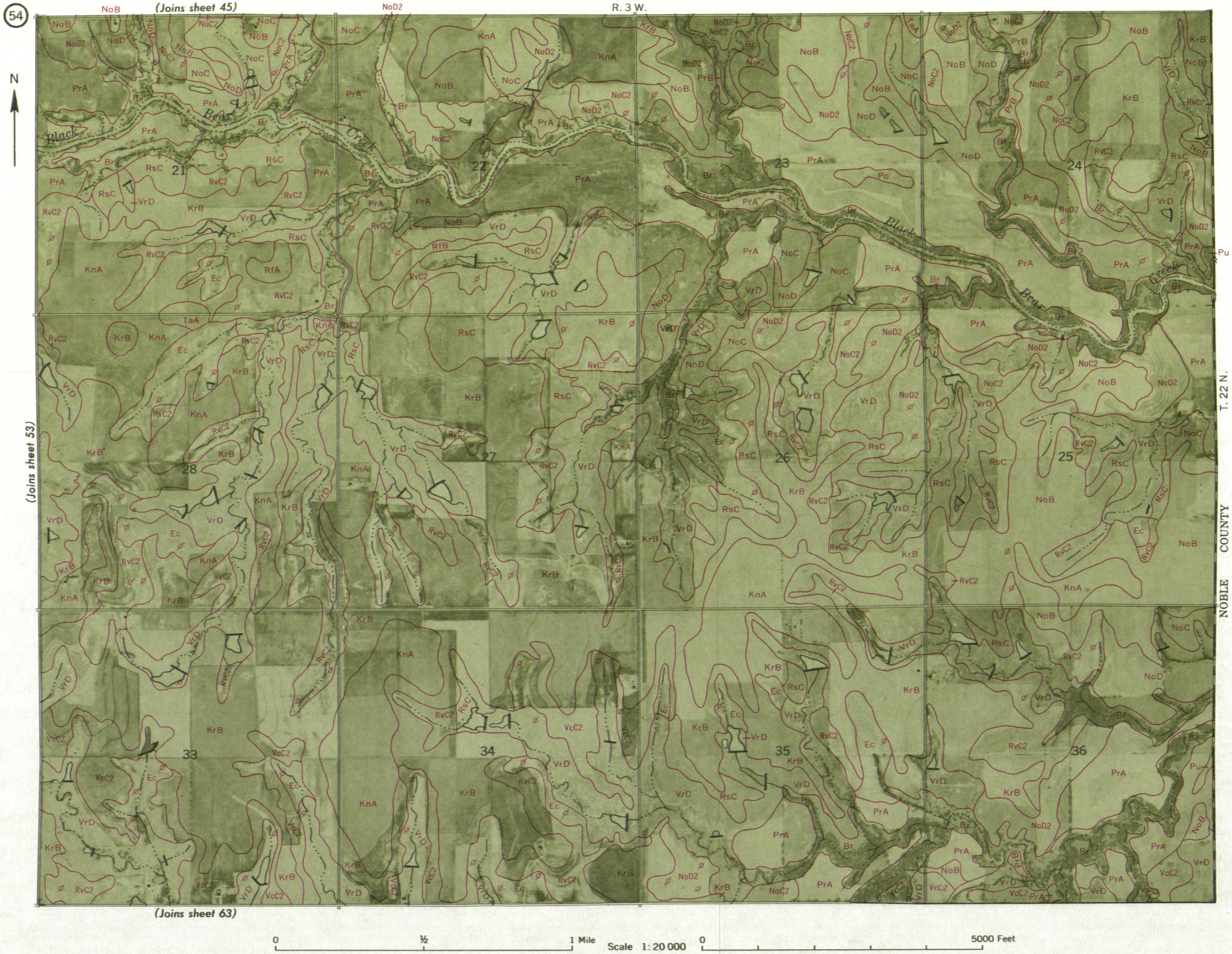
GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 52

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

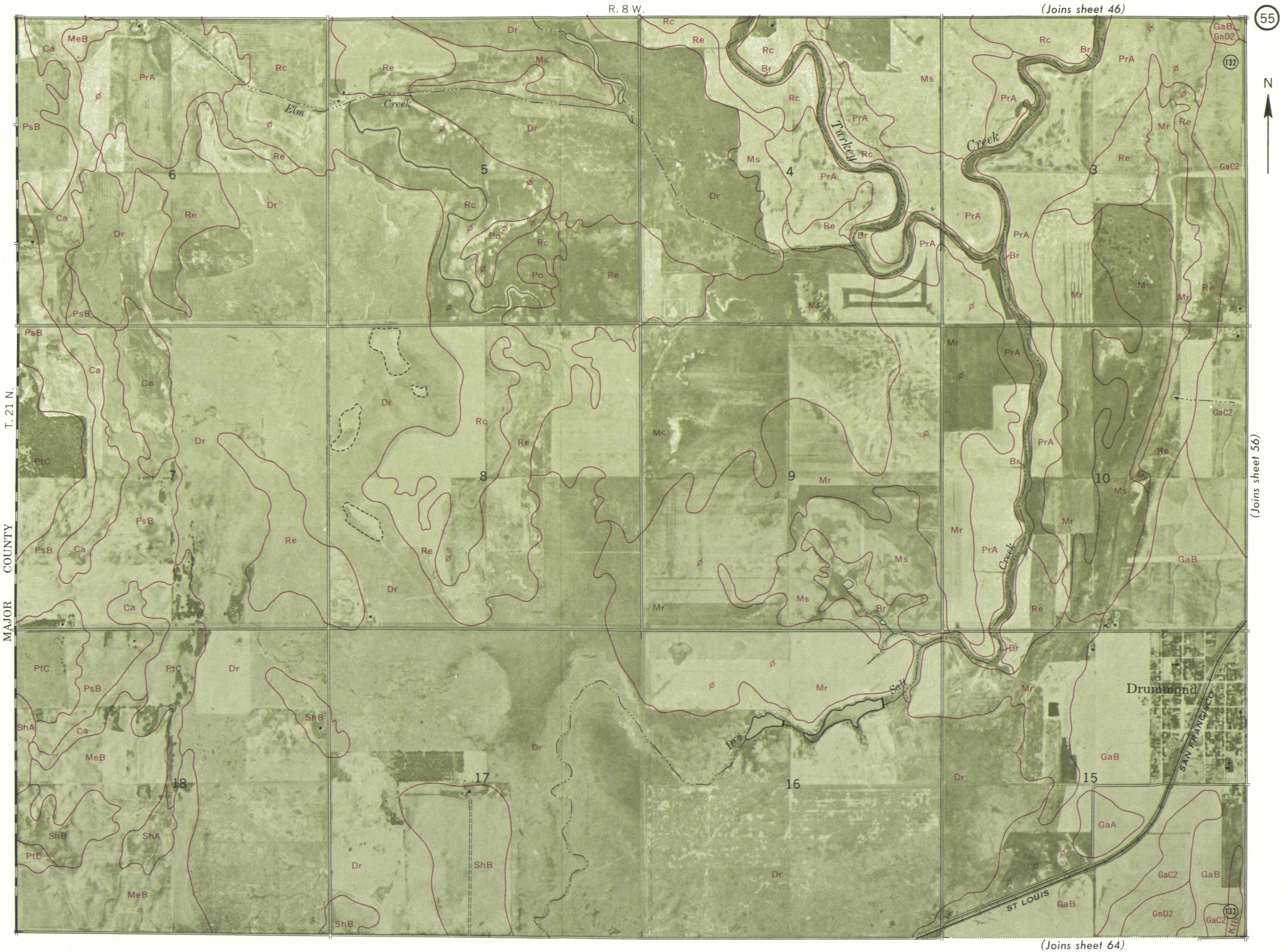
Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet


54
(Joins sheet 45)
R. 3 W.
N
(Joins sheet 53)
T. 22 N.
NOBLE COUNTY
Black Bear Creek
21
22
23
24
28
27
26
25
33
34
35
36
(Joins sheet 63)
0 ½ 1 Mile
Scale 1:20 000
0 5000 Feet

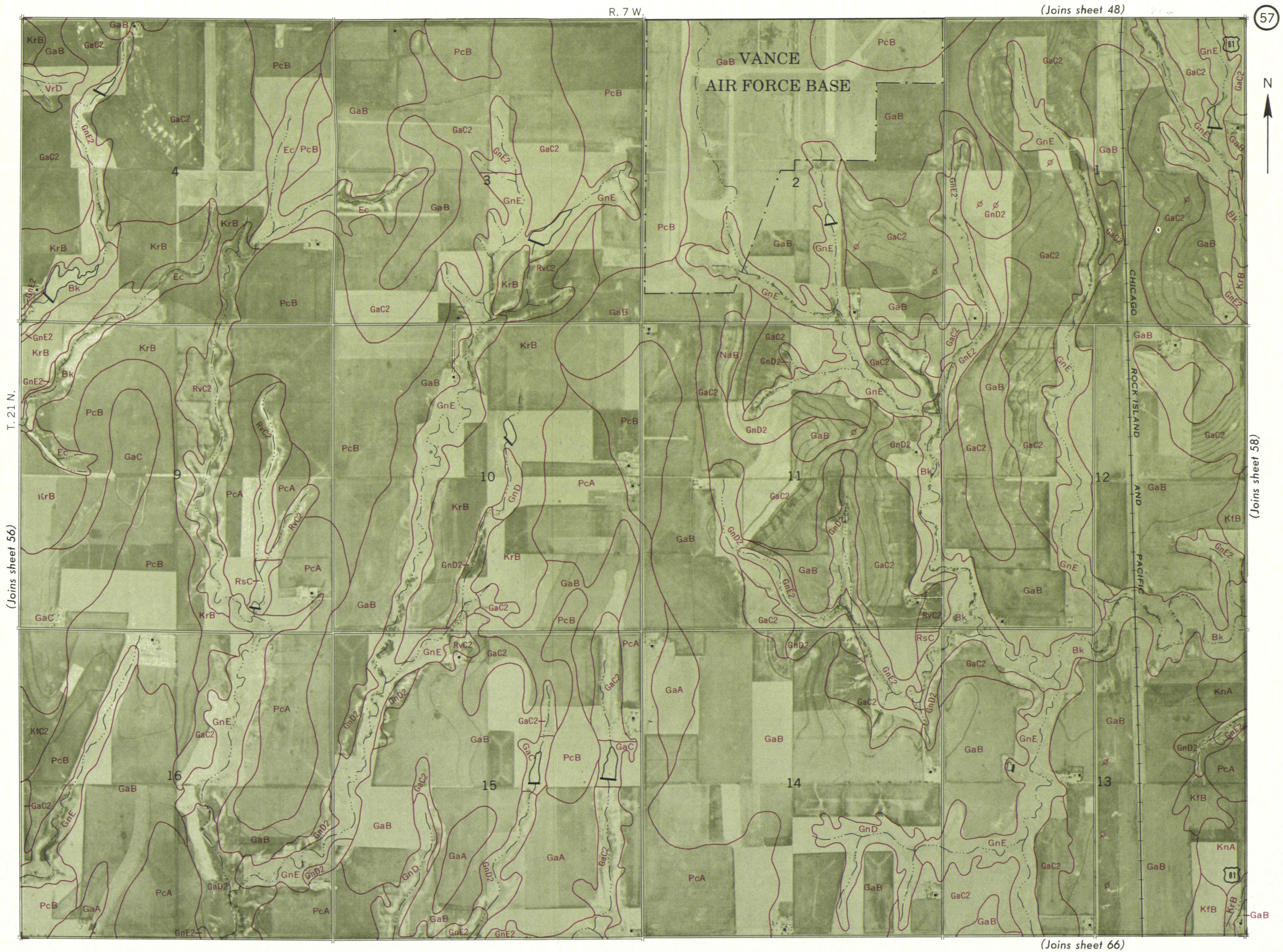
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

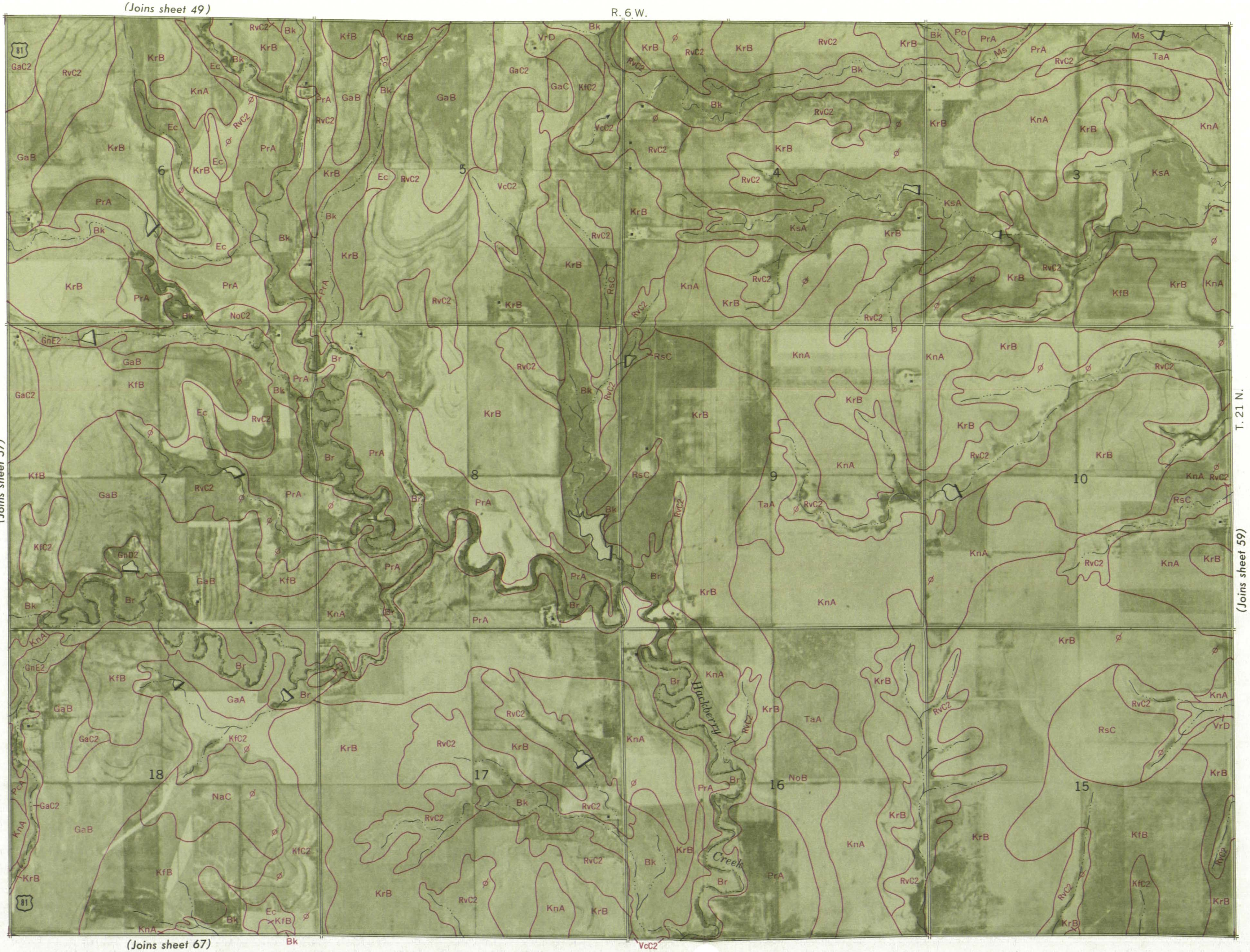


0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

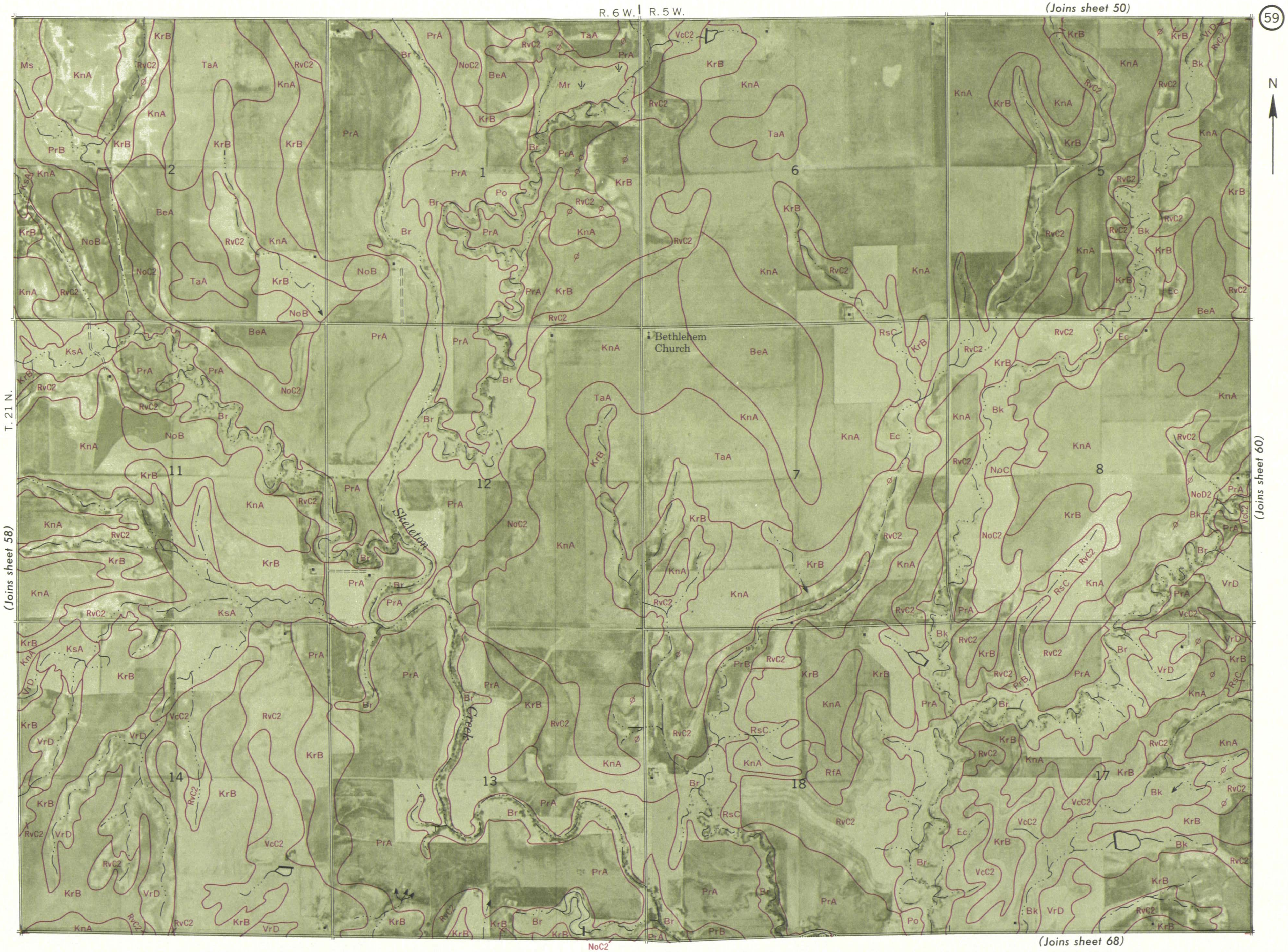
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

58



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

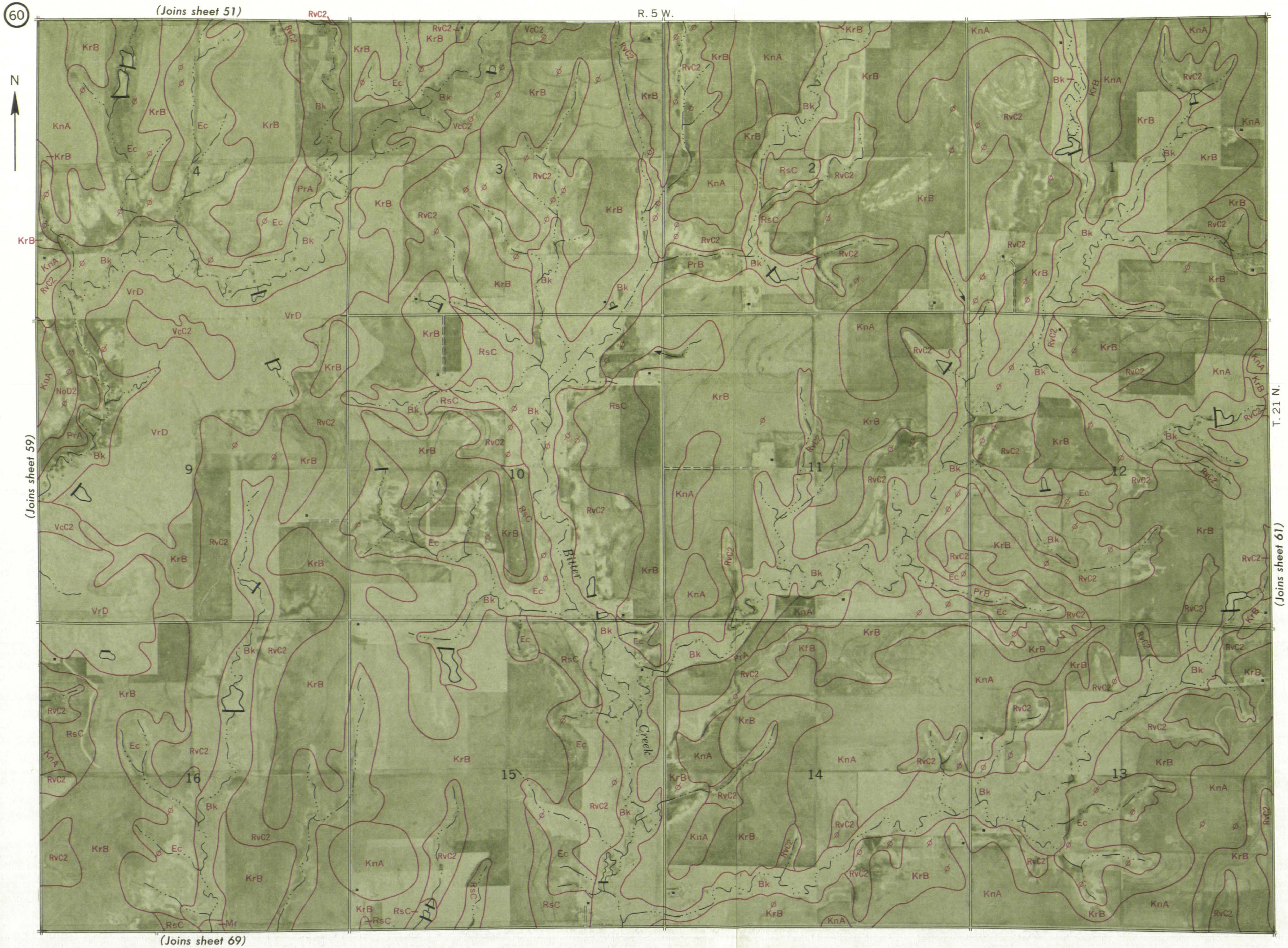


0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

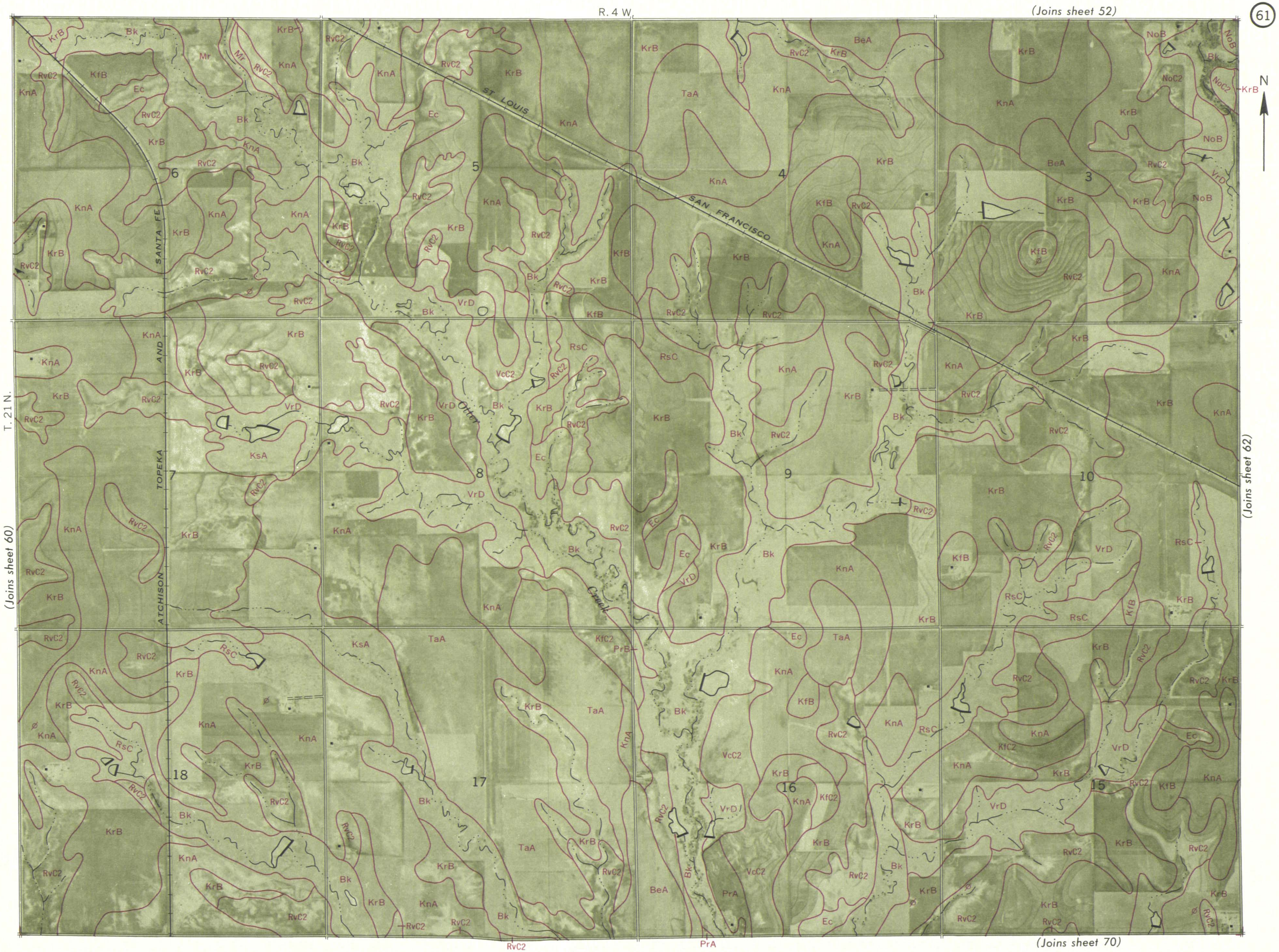
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



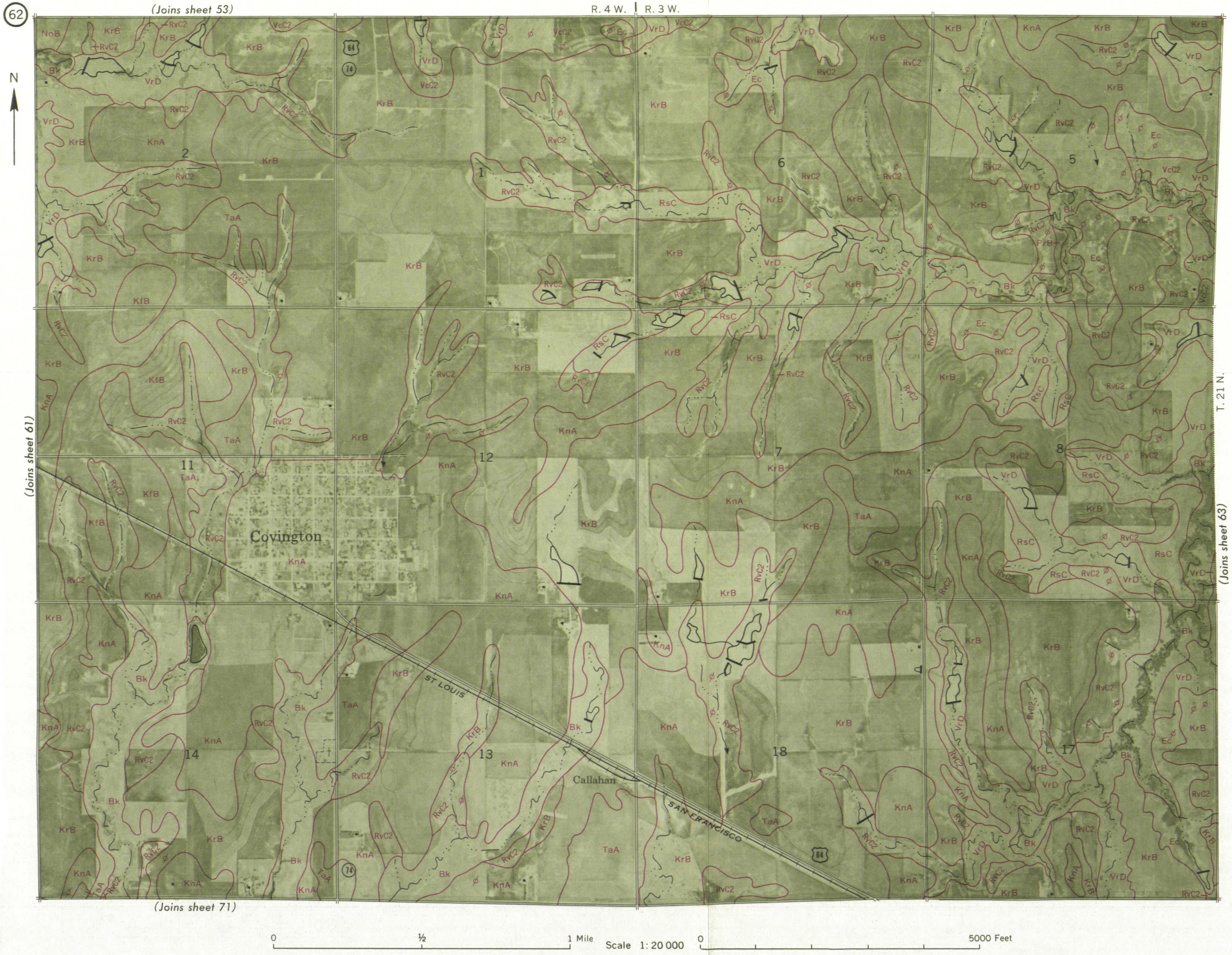
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet


62
(Joins sheet 53)
R. 4 W.
R. 3 W.
(Joins sheet 61)
(Joins sheet 63)
(Joins sheet 71)
T. 21 N.
N
Covington
Callahan
ST LOUIS
SAN FRANCISCO
64
74
1
2
5
6
7
8
11
12
13
14
17
18
KrB
KnA
RvC2
VrD
TaA
KfB
Bk
Ec
RsC
VcC2
NoB
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

Scale 1: 20 000

0 ½ 1 Mile

0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

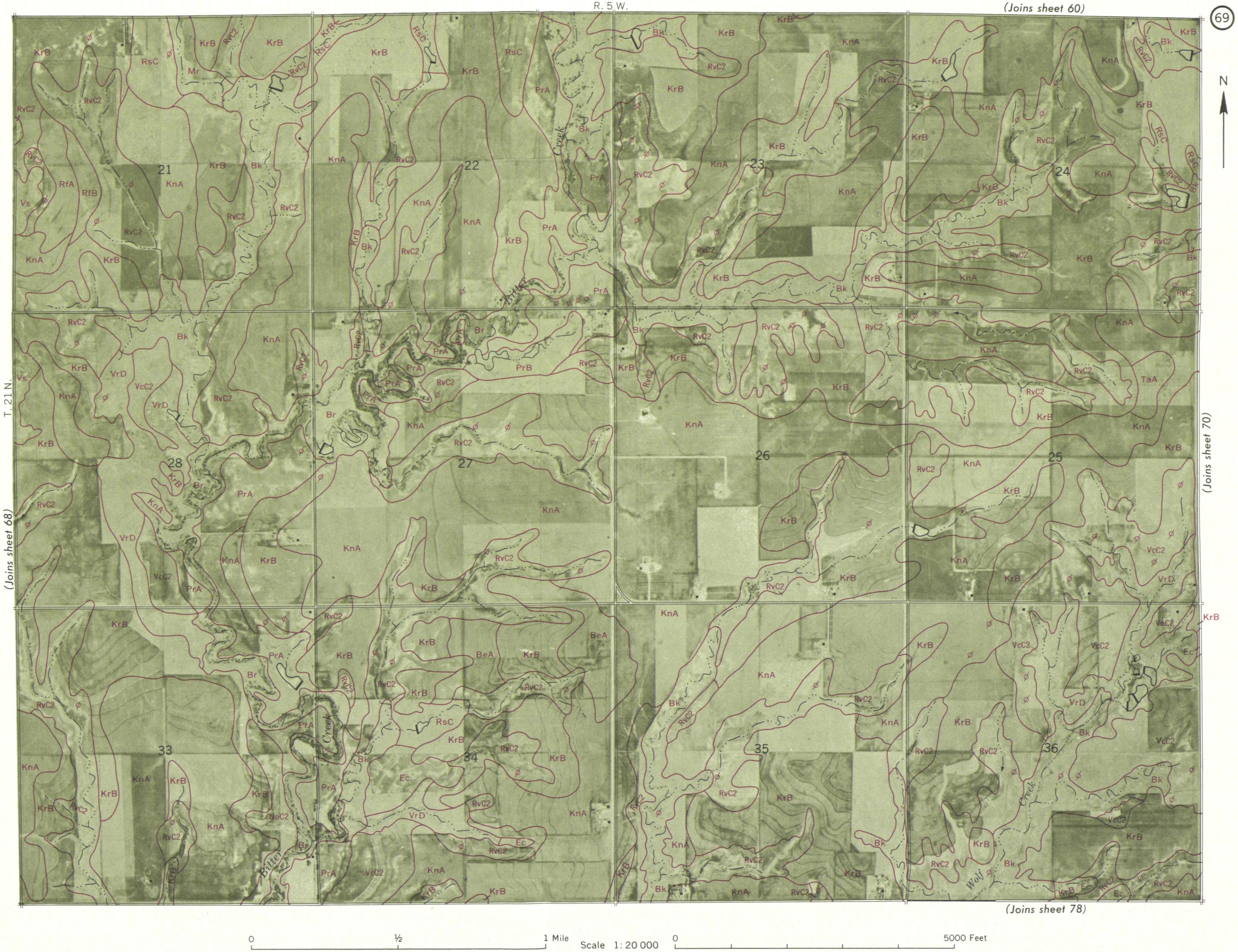
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

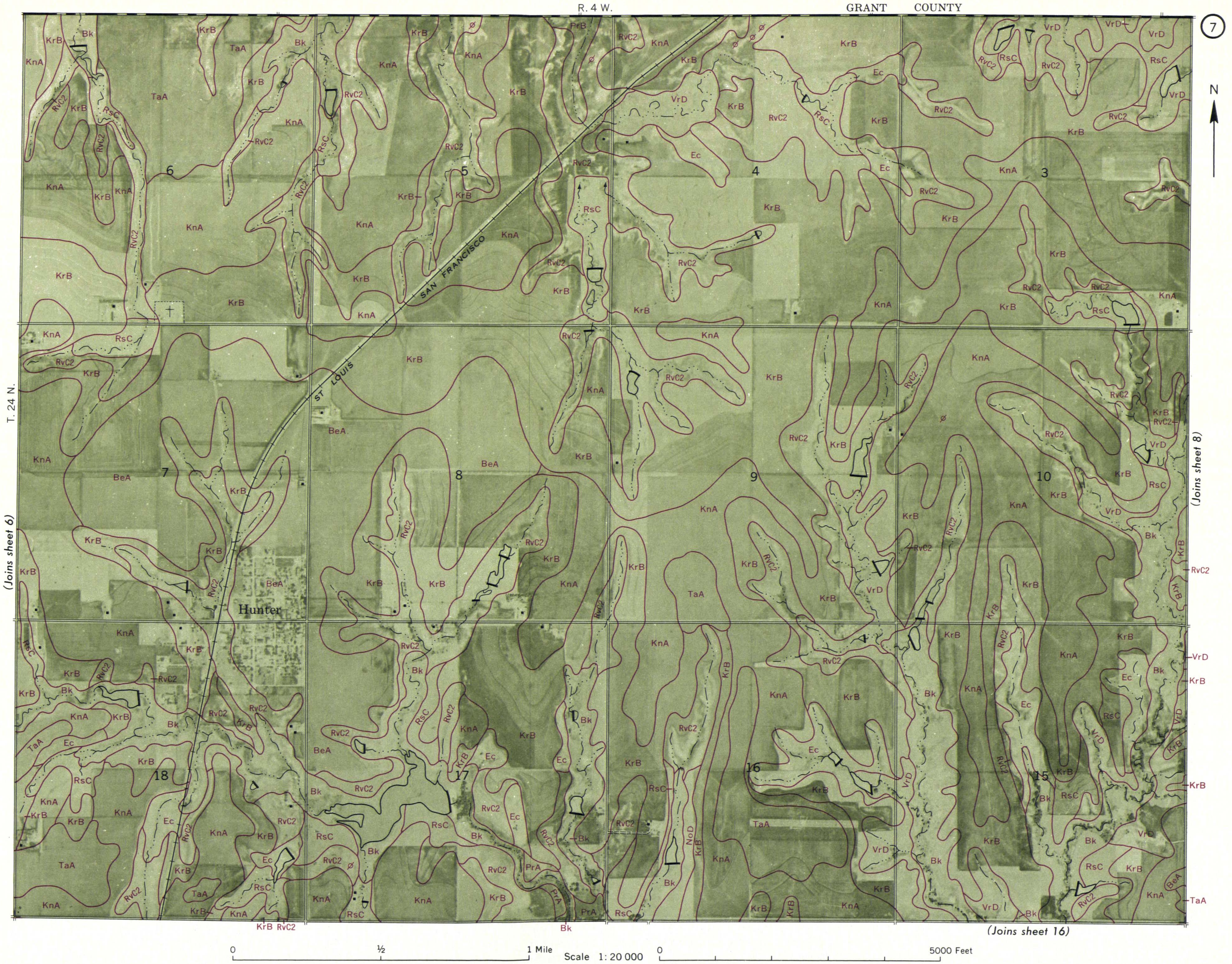
Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

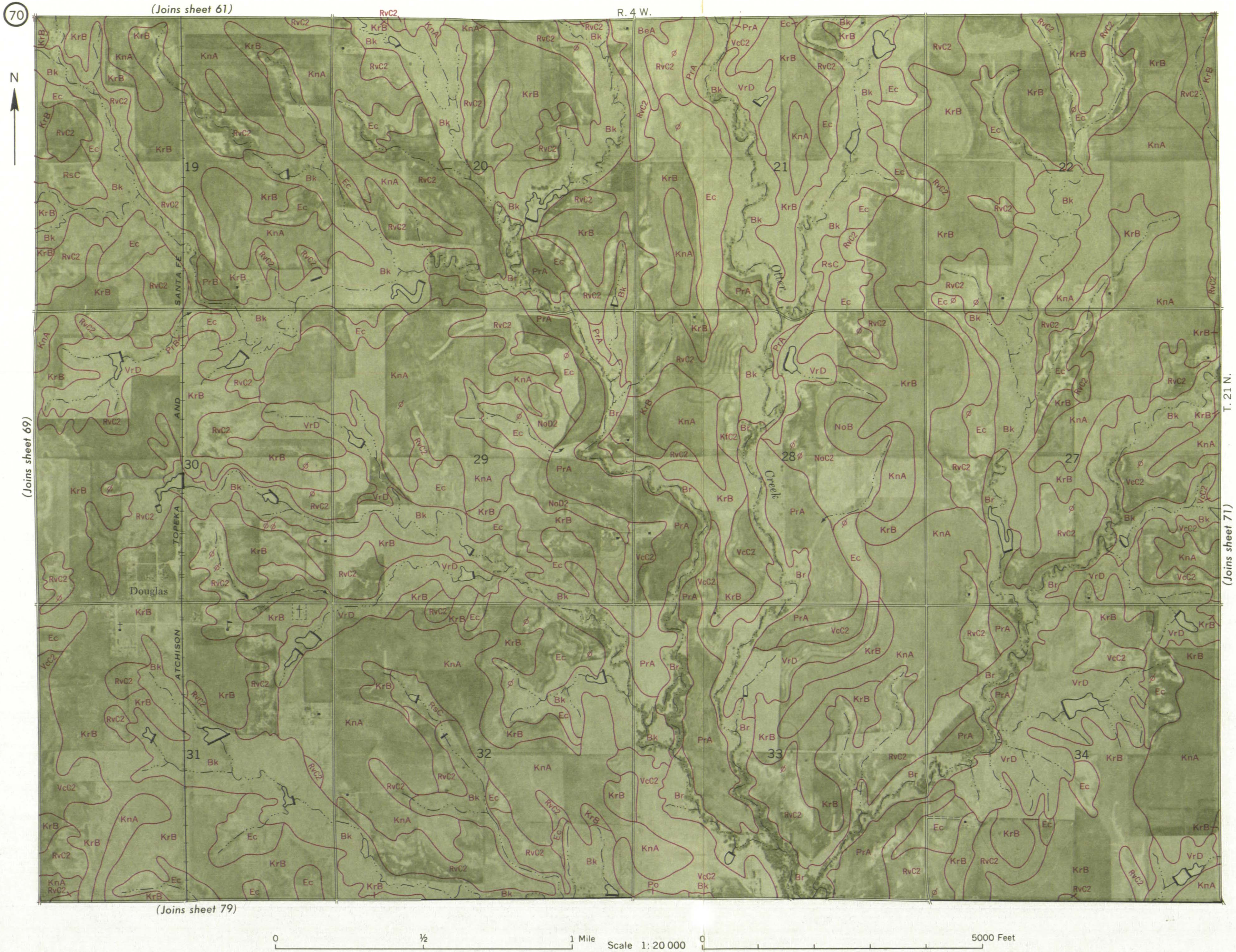
Range, township, and section corners shown on this map are indefinite.



This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

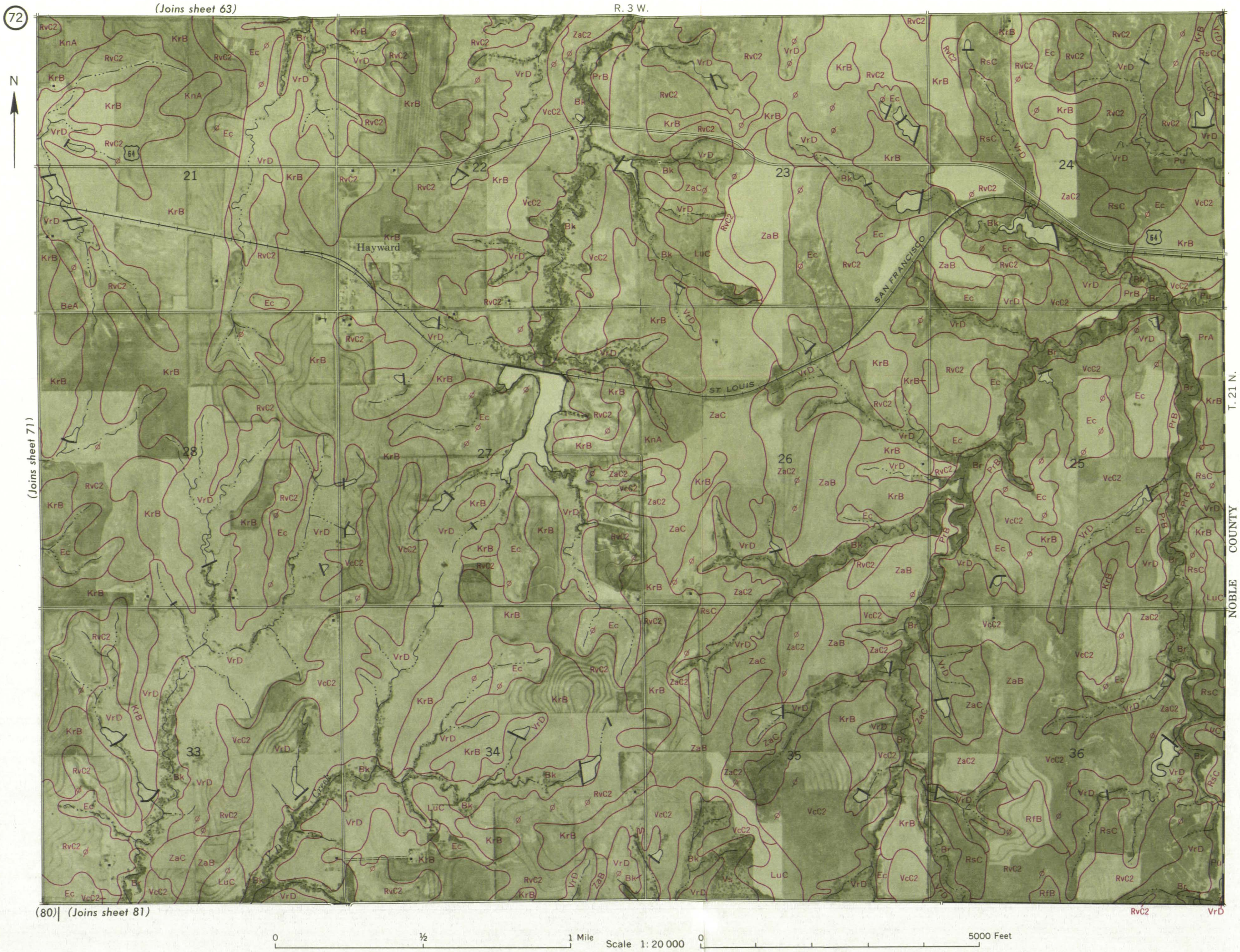
GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 70



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

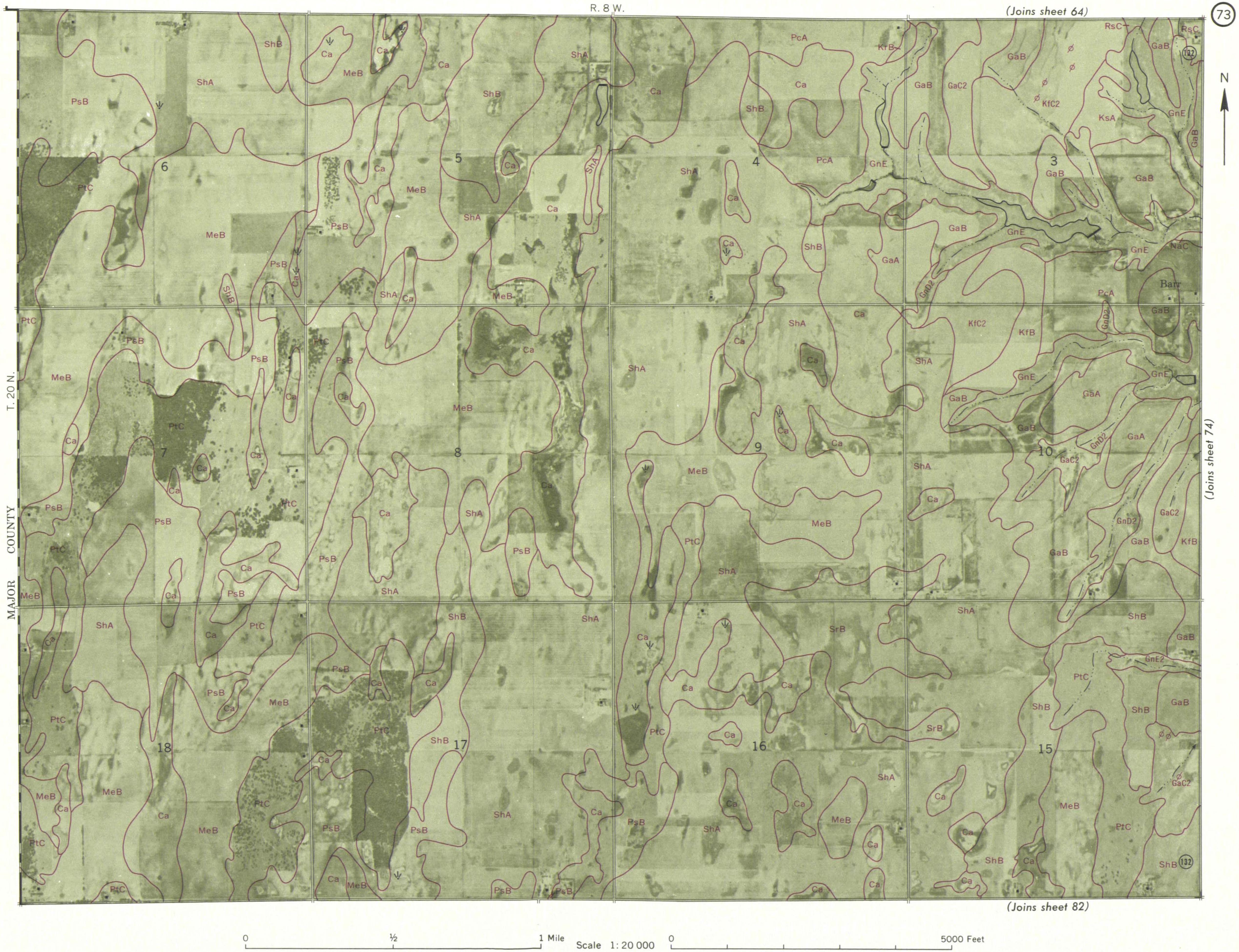
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.


72
(Joins sheet 63)
R. 3 W.
N
Hayward
ST. LOUIS – SAN FRANCISCO
21
22
23
24
28
27
26
25
33
34
35
36
(Joins sheet 71)
T. 21 N.
NOBLE COUNTY
(80)
(Joins sheet 81)
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 74

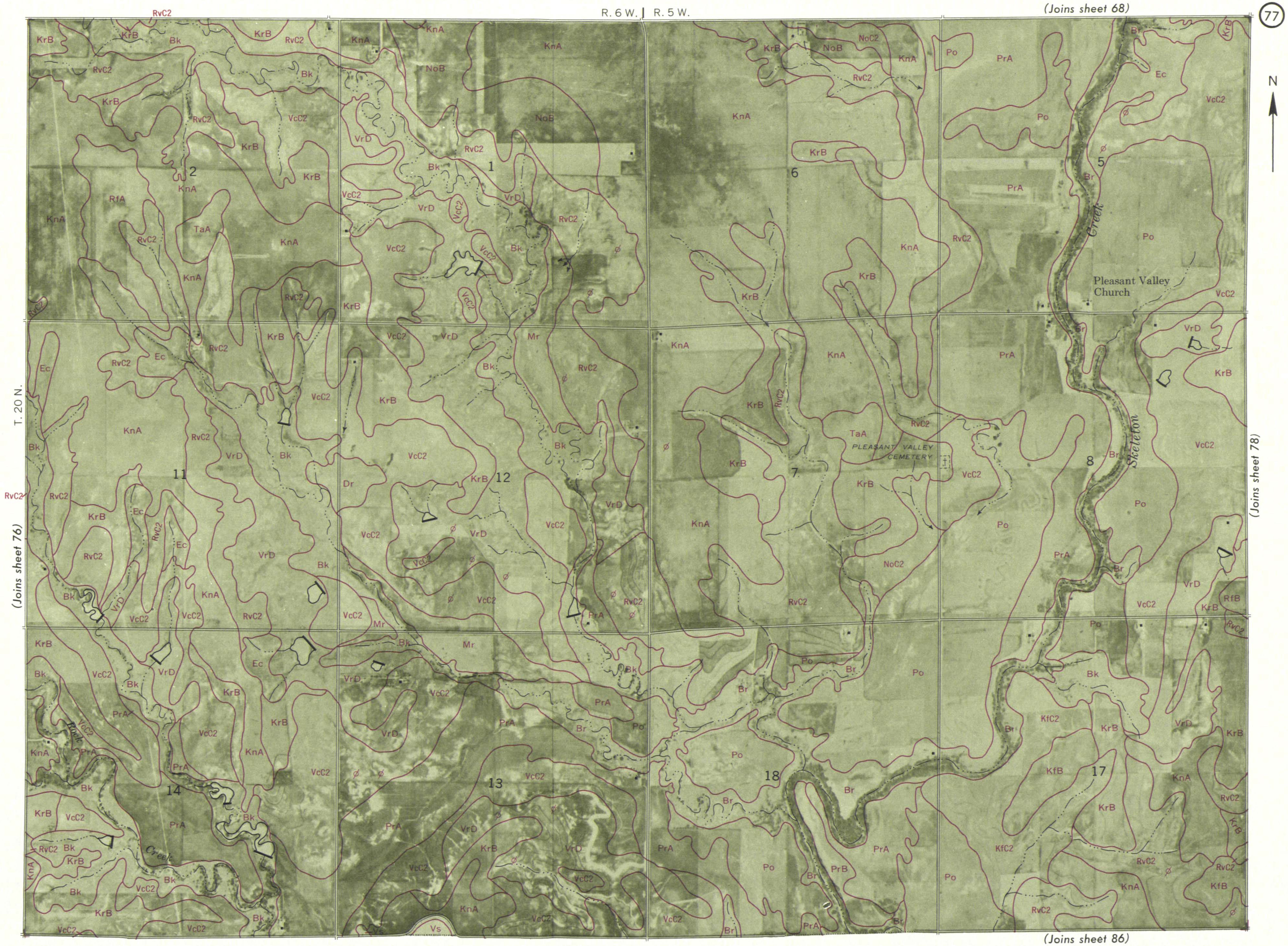
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

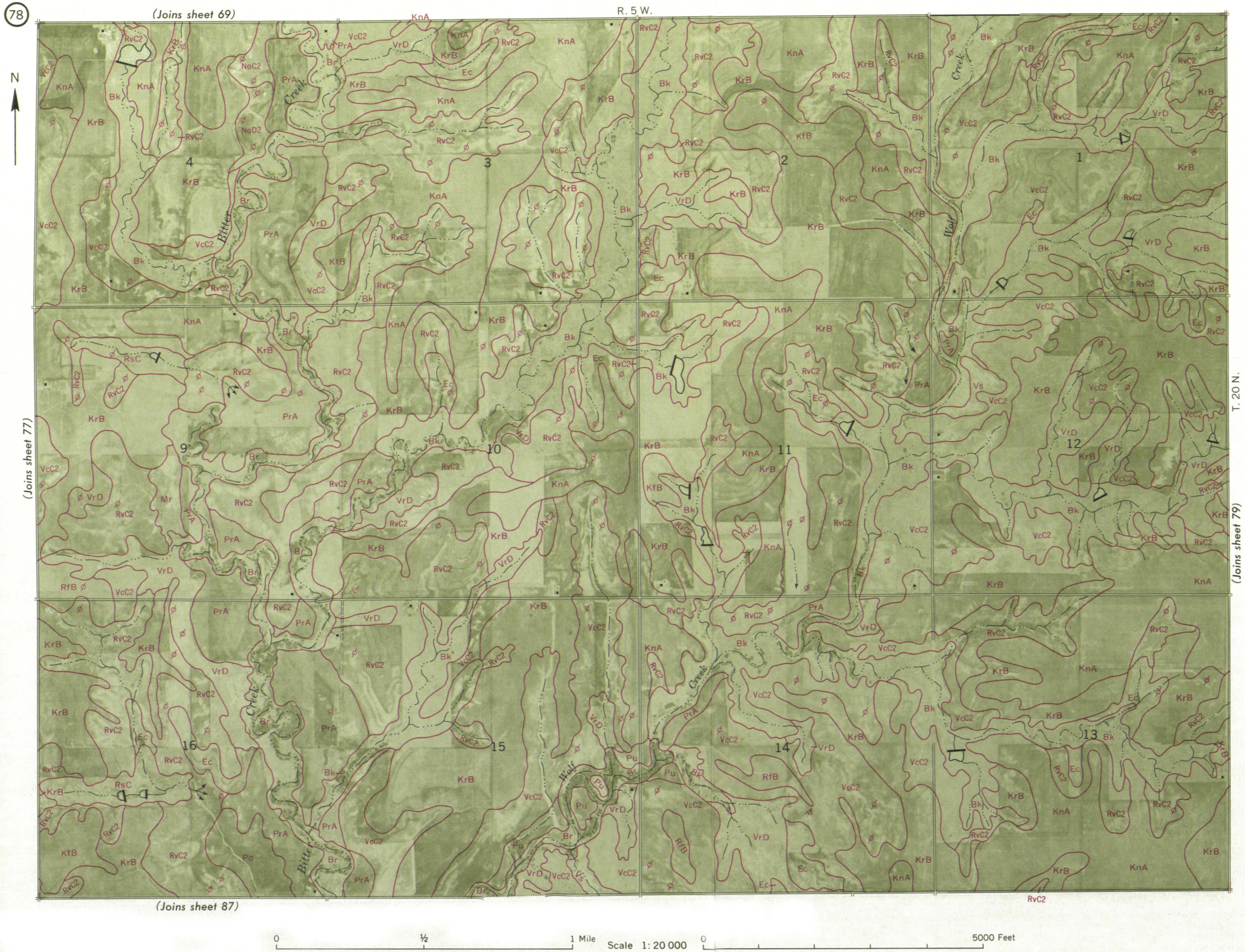

76
(Joins sheet 67)
R. 6 W.
(Joins sheet 67)
(68)
N
(Joins sheet 75)
(Joins sheet 77)
T. 20 N.
(Joins sheet 85)
6
5
4
3
7
8
9
10
18
17
16
15
Rock Creek
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet



This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

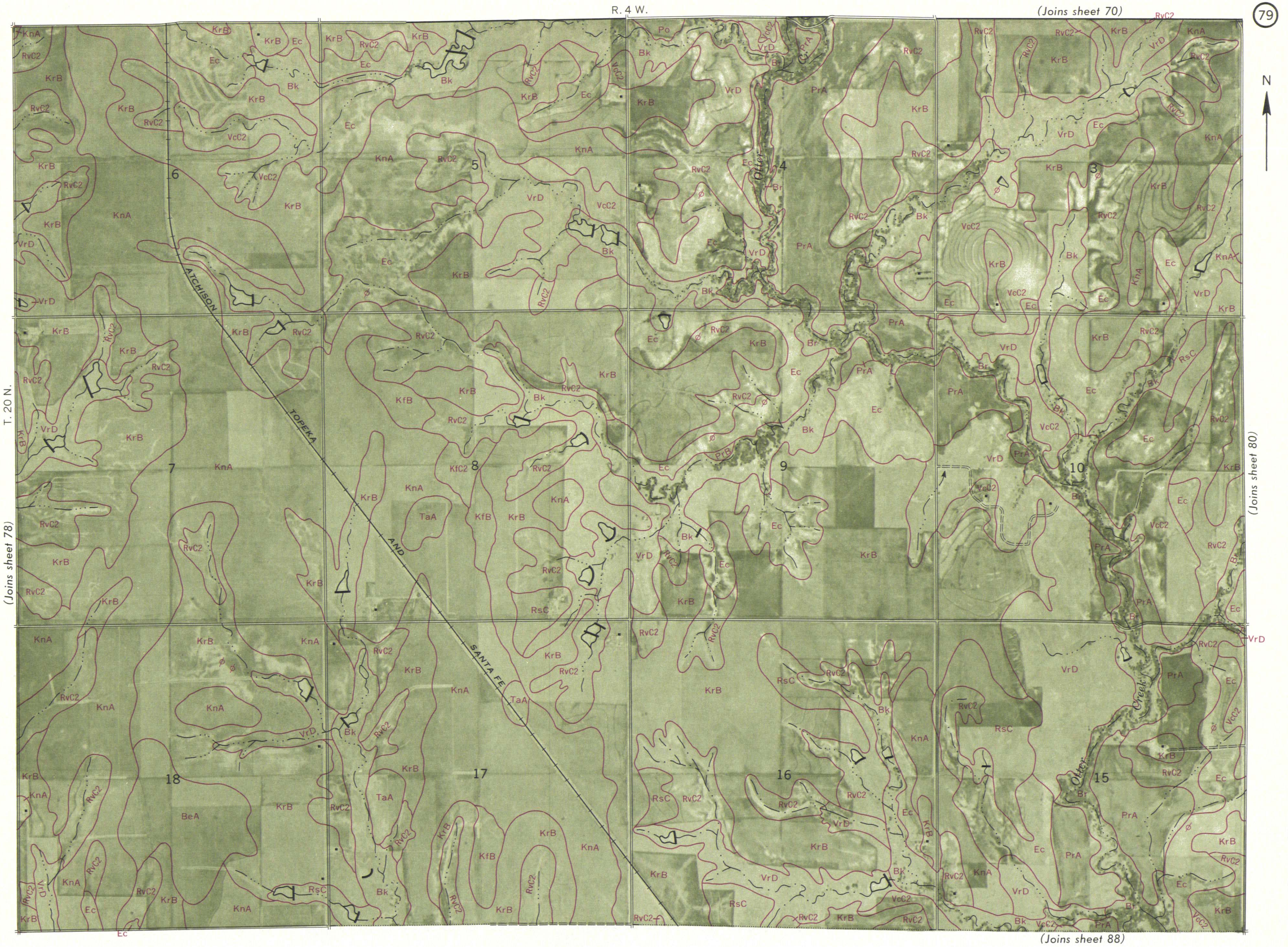
Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

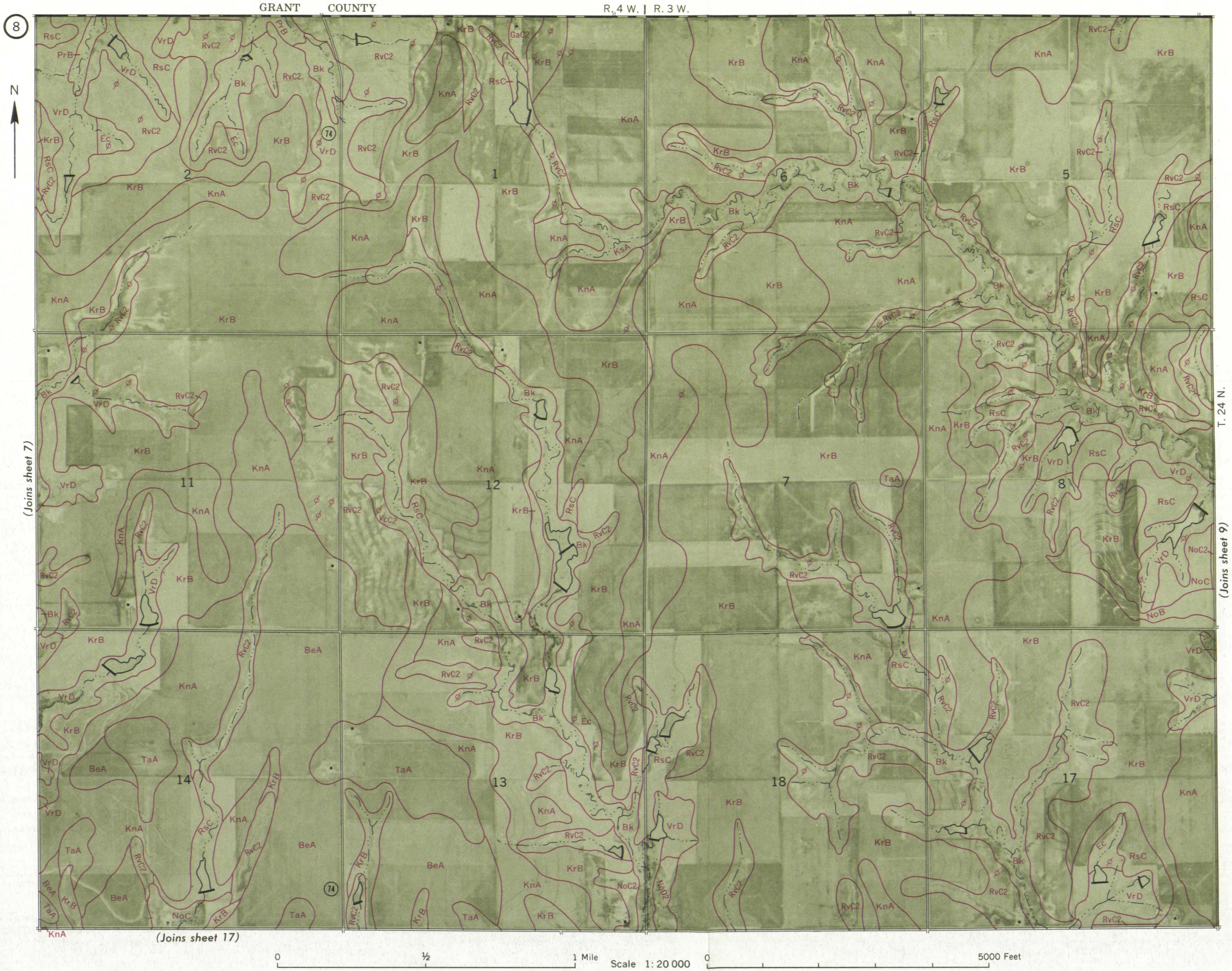

78
(Joins sheet 69)
R. 5 W.
N
(Joins sheet 77)
T. 20 N.
(Joins sheet 79)
(Joins sheet 87)
Bitter Creek
Wolf Creek
1
2
3
4
9
10
11
12
13
14
15
16
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

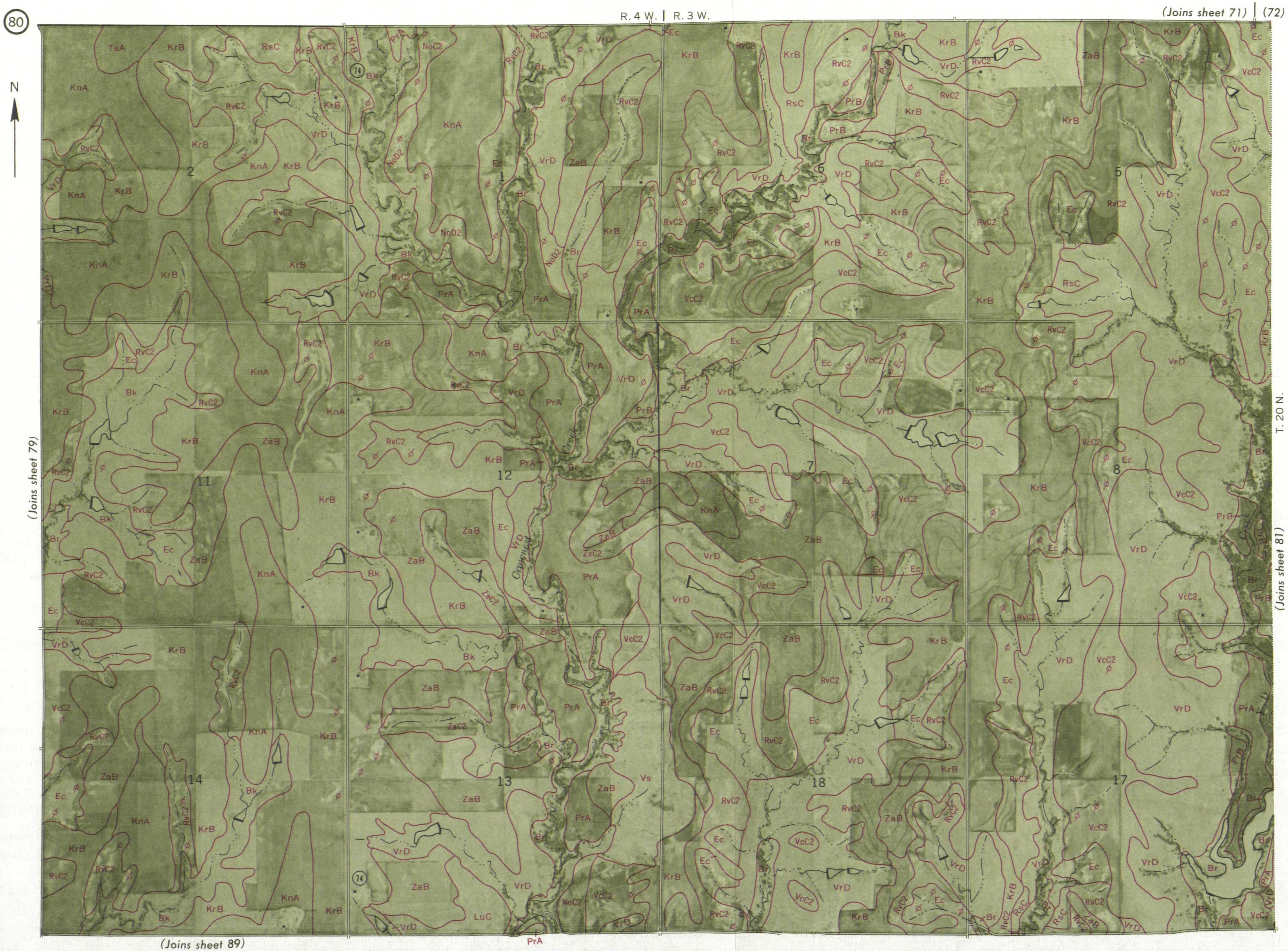
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet


8
GRANT COUNTY
R. 4 W. | R. 3 W.
N
T. 24 N.
(Joins sheet 7)
(Joins sheet 9)
(Joins sheet 17)
1
2
5
6
7
8
11
12
13
14
17
18
74
0 ½ 1 Mile
Scale 1:20 000
0 5000 Feet



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 82

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 83

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet


84
(Joins sheet 75)
R. 7 W.
N
(Joins sheet 83)
(Joins sheet 85)
T. 20 N.
KINGFISHER COUNTY
Bison
CHICAGO ROCK ISLAND AND PACIFIC
21
22
23
24
28
27
26
25
33
34
35
36
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 86

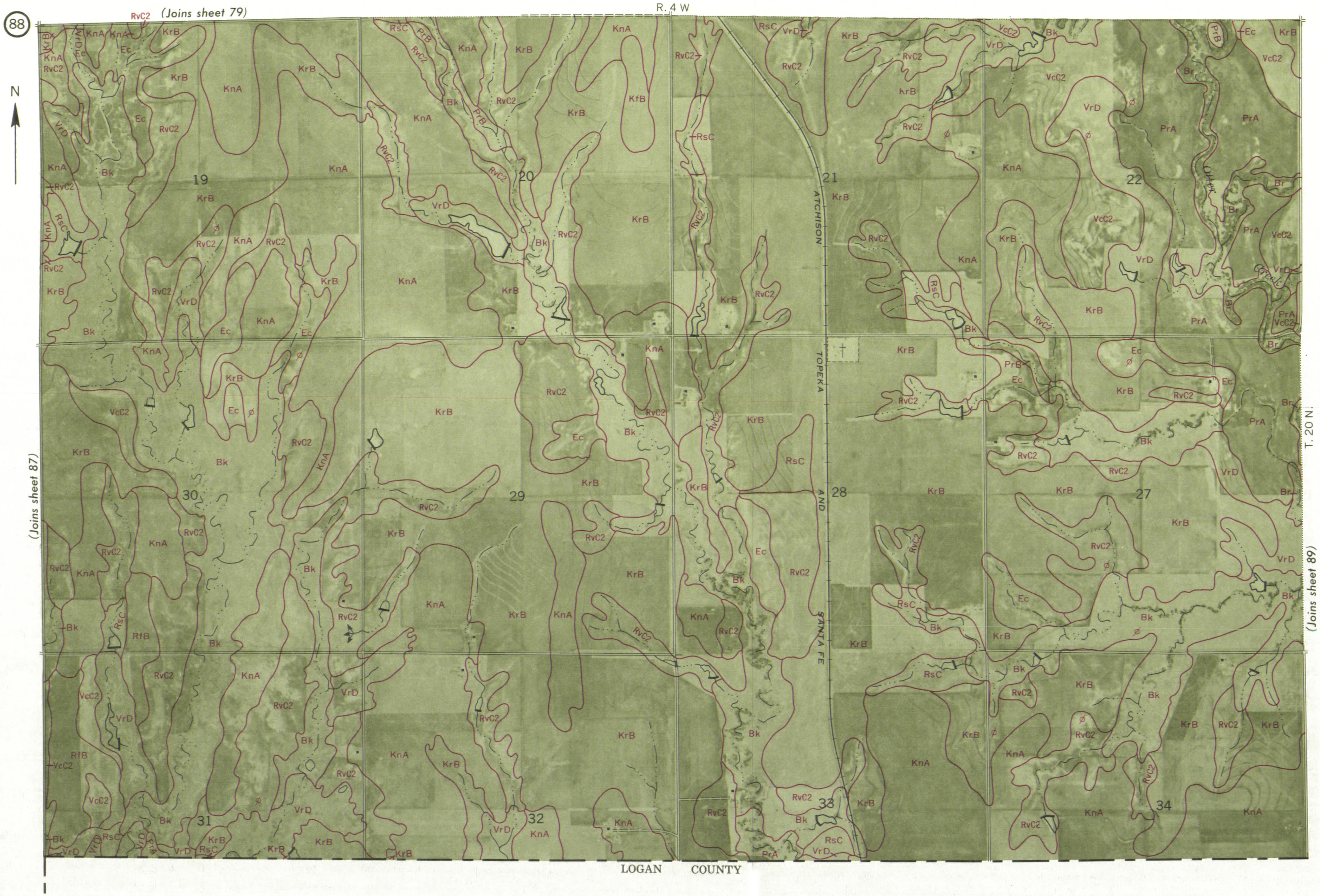
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 87

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

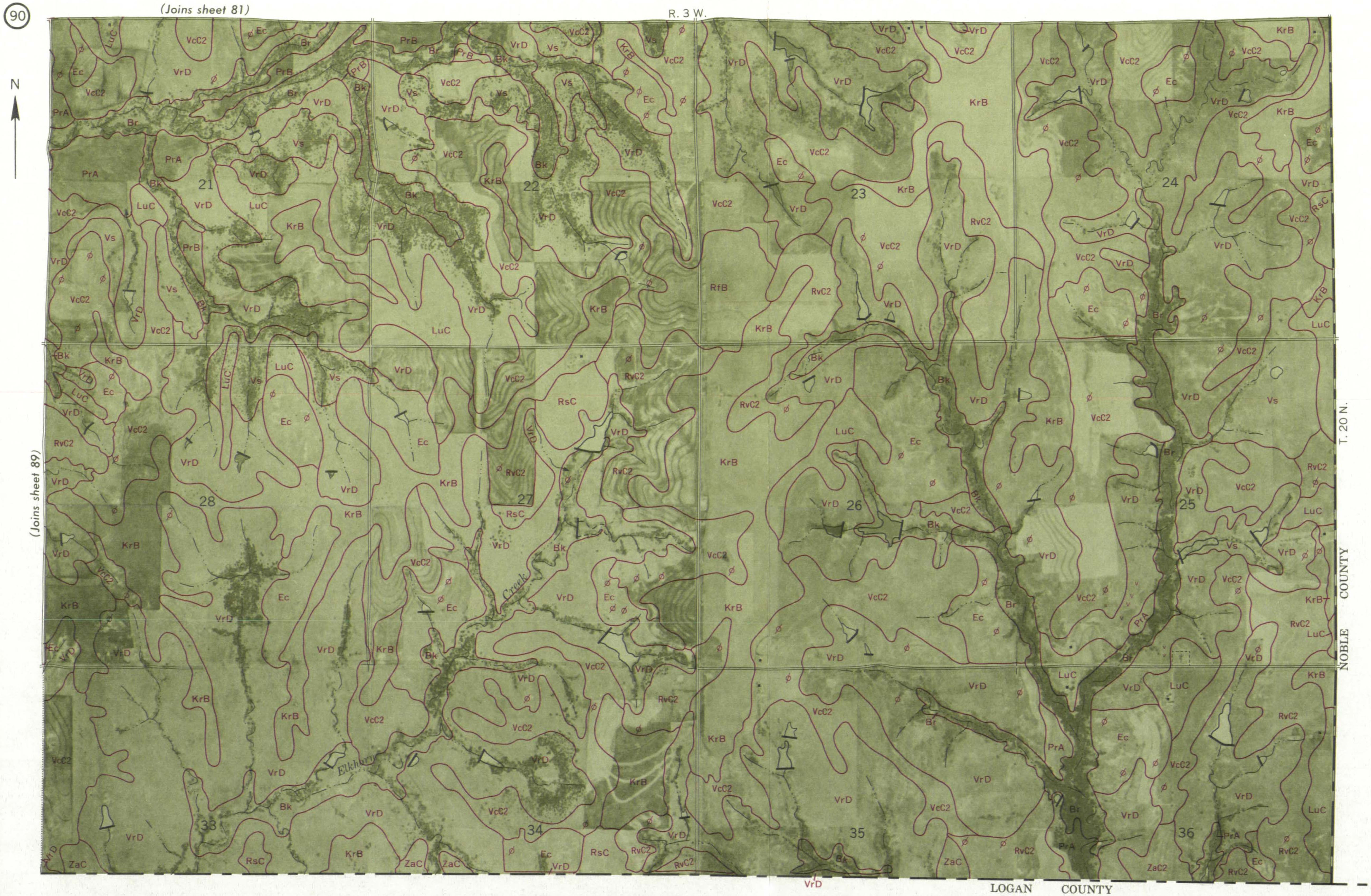
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

GARFIELD COUNTY, OKLAHOMA — SHEET NUMBER 9

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Range, township, and section corners shown on this map are indefinite.

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

GUIDE TO MAPPING UNITS

[For a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which it belongs.

[See table 1, page 7, for approximate acreage and proportionate extent of the soils and table 2, page 29, for estimated yields for each soil under dryland farming. Descriptions of range sites are on pages 30 and 31, and descriptions of woodland suitability groups are on pages 31 and 32. For information significant to engineering, see the subsection beginning on page 33]

Map symbol	Mapping unit	Described on page	Capability unit		Range site	Woodland suitability group
			Symbol	Page	Name	Number
BeA	Bethany silt loam, 0 to 1 percent slopes	7	I-2	22	Loamy Prairie	2
Bk	Breaks-Alluvial land complex	8				
	Breaks	--	VIe-2	27	Loamy Prairie	2
	Alluvial	--	VIe-2	27	Loamy Bottom Land	2
Br	Broken alluvial land	8	Vw-1	27	Loamy Bottom Land	2
Ca	Carwile loam	8	IIw-1	23	Loamy Prairie	2
Dr	Drummond soils	9	Vs-1	27	Saline Subirrigated	4
Ec	Eroded clayey land	9	VIe-3	27	Eroded Clay	4
GaA	Grant silt loam, 0 to 1 percent slopes	9	I-2	22	Loamy Prairie	2
GaB	Grant silt loam, 1 to 3 percent slopes	9	IIe-2	23	Loamy Prairie	2
GaC	Grant silt loam, 3 to 5 percent slopes	9	IIIe-1	24	Loamy Prairie	2
GaC2	Grant silt loam, 3 to 5 percent slopes, eroded	9	IIIe-2	24	Loamy Prairie	3
GnD	Grant-Nash silt loams, 5 to 8 percent slopes	10	IVe-1	25	Loamy Prairie	3
GnD2	Grant-Nash silt loams, 5 to 8 percent slopes, eroded	10	IVe-2	25	Loamy Prairie	3
GnE	Grant-Nash silt loams, 8 to 20 percent slopes	10	VIe-1	27	Loamy Prairie	4
GnE2	Grant-Nash silt loams, 8 to 20 percent slopes, eroded	10	VIe-4	27	Loamy Prairie	4
KfB	Kingfisher silt loam, 1 to 3 percent slopes	10	IIe-1	22	Loamy Prairie	2
KfC2	Kingfisher silt loam, 2 to 5 percent slopes, eroded	10	IIIe-2	24	Loamy Prairie	3
KlD2	Kingfisher-Lucien complex, 5 to 8 percent slopes, eroded	11				
	Kingfisher soil	--	IVe-2	25	Loamy Prairie	3
	Lucien soil	--	IVe-2	25	Shallow Prairie	3
KnA	Kirkland silt loam, 0 to 1 percent slopes	11	IIs-1	23	Claypan Prairie	3
KrB	Kirkland-Renfrow silt loams, 1 to 3 percent slopes	11	IIIe-3	24	Claypan Prairie	3
KsA	Kirkland-Slickspots complex, 0 to 1 percent slopes	11				
	Kirkland soil	--	IVs-2	26	Claypan Prairie	4
	Slickspots	--	IVs-2	26	Slickspot	4
LuC	Lucien very fine sandy loam, 3 to 5 percent slopes	12	IVe-6	26	Shallow Prairie	3
MeB	Meno loamy fine sand, undulating	12	IIe-3	23	Deep Sand	1
Mr	Miller clay	13	IIIw-1	24	Heavy Bottom Land	4
Ms	Miller-Slickspots complex	13				
	Miller soil	--	IVs-1	26	Heavy Bottom Land	4
	Slickspots	--	IVs-1	26	Alkali Bottom Land	4
NaB	Nash silt loam, 1 to 3 percent slopes	13	IIe-2	23	Loamy Prairie	3
NaC	Nash silt loam, 3 to 5 percent slopes	13	IIIe-1	24	Loamy Prairie	3
NoB	Norge loam, 1 to 3 percent slopes	14	IIe-1	22	Loamy Prairie	2
NoC	Norge loam, 3 to 5 percent slopes	14	IIIe-1	24	Loamy Prairie	3
NoC2	Norge loam, 3 to 5 percent slopes, eroded	14	IIIe-2	24	Loamy Prairie	3
NoD	Norge loam, 5 to 8 percent slopes	14	IVe-1	25	Loamy Prairie	3
NoD2	Norge loam, 5 to 8 percent slopes, eroded	14	IVe-2	25	Loamy Prairie	3
PcA	Pond Creek silt loam, 0 to 1 percent slopes	15	I-2	22	Loamy Prairie	2
PcB	Pond Creek silt loam, 1 to 3 percent slopes	15	IIe-1	22	Loamy Prairie	2
Po	Port clay loam	15	IIw-2	23	Loamy Bottom Land	1
PrA	Port silt loam, 0 to 1 percent slopes	15	IIw-2	23	Loamy Bottom Land	1
PrB	Port silt loam, 1 to 3 percent slopes	15	IIe-4	23	Loamy Bottom Land	1
PsB	Pratt loamy fine sand, undulating	16	IIIe-4	24	Deep Sand	2
PtC	Pratt loamy fine sand, hummocky	16	IVe-5	26	Deep Sand	2
Pu	Pulaski fine sandy loam	17	IIw-2	23	Loamy Bottom Land	1
Rc	Reinach loam	17	I-1	22	Loamy Bottom Land	1
Re	Reinach-Slickspots complex	17				
	Reinach soil	--	IIIs-1	25	Loamy Bottom Land	2
	Slickspots	--	IIIs-1	25	Alkali Bottom Land	2
RfA	Renfrow clay loam, 0 to 1 percent slopes	18	IIs-1	23	Claypan Prairie	3
RfB	Renfrow clay loam, 1 to 3 percent slopes	18	IIIe-3	24	Claypan Prairie	3
RsC	Renfrow silt loam, 3 to 5 percent slopes	18	IVe-3	25	Claypan Prairie	3
RvC2	Renfrow-Vernon complex, 3 to 5 percent slopes, eroded	18				
	Renfrow soil	--	IVe-4	26	Claypan Prairie	3
	Vernon soil	--	IVe-4	26	Red Clay Prairie	3
ShA	Shellabarger fine sandy loam, 0 to 1 percent slopes	19	IIe-3	23	Sandy Prairie	1
ShB	Shellabarger fine sandy loam, 1 to 3 percent slopes	19	IIe-3	23	Sandy Prairie	1
SrB	Shellabarger-Carwile fine sandy loams, undulating	19	IIw-1	23	Sandy Prairie	1
TaA	Tabler silt loam, 0 to 1 percent slopes	20	IIs-1	23	Claypan Prairie	3
VcC2	Vernon clay loam, 3 to 5 percent slopes, eroded	20	IVe-4	26	Red Clay Prairie	3
VrD	Vernon soils, 5 to 12 percent slopes	20	VIe-2	27	Red Clay Prairie	4
Vs	Vernon soils and Rock outcrop	20	VIIs-1	28	Eroded Red Clay	4
WoB	Weymouth-Ost loams, undulating	21	IIe-1	22	Loamy Prairie	2
ZaB	Zaneis loam, 1 to 3 percent slopes	21	IIe-1	22	Loamy Prairie	2
ZaC	Zaneis loam, 3 to 5 percent slopes	21	IIIe-1	24	Loamy Prairie	3
ZaC2	Zaneis loam, 3 to 5 percent slopes, eroded	21	IIIe-2	24	Loamy Prairie	3

234-147 O - 67 (Inside back cover)